LIST OF THE OFFICERS

OF

The Institution of Petroleum Technologists, 1933-1934

Past-Presidents:

*Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. (1914-1916).
Prof. Sir John Cadman, G.C.M.G., D.Sc., M.Inst.C.E., M.Inst.M.M. (1916).
The Rt. Hon. Lord Greenway of Stanbridge Earls (1917-1919). (1917).
*Sir Frederick W. Black, K.C.B., B.A. (Lond.) (1919-1921).
Prof. John Samuel Strafford Brame, C.B.E., F.I.C., F.C.S. (1921-1923).
*Herbert Barringer, M.Inst.C.E., M.I.Mech.E., M.I.N.A., M.Inst.Mar.Eng. (1923-1925).
Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S. (1925-1927).
Alfred C. Adams (1927-1929).
A. E. Dunstan, D.Sc., F.I.C., F.C.S. (1929-1931).
James Kewley, M.A., F.I.C., F.C.S. (1931-1933).

President:

T. Dewhurst, A.R.C.Sc., F.G.S.

Vice-Presidents:

Ashley Carter, A.M.I.Mech.E.
C. Dalley, M.I.E.E.
Alexander Duckham, F.C.S.
Arthur W. Eastlake, M.I.Min.E., A.M.I.Mech.E.
J. McConnell Sanders, F.I.C., F.C.S.
F. B. Thole, D.Sc., F.I.C., F.C.S.

Members of Council:

Lt.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc.
Sir John T. Cargill, Bart., Hon. LL.D.
A. E. Chambers, A.M.Inst.C.E.
G. H. Coxon.
A. Frank Dabell, M.I.Mech.E.
B. J. Ellis.
Elliott A. Evans, F.C.S.
F. H. Garner, Ph.D., M.Sc., F.I.C.
T. R. H. Garrett, M.A., F.G.S.
John Gillespie, M.I.Mech.E.
Prof. V. C. Illing.
J. S. Jackson, B.Sc., A.I.C.
Prof. A. W. Nash, M.Sc., F.C.S., M.I.Mech.E.
James Romanes, F.G.S.
A. Beeby Thompson, O.B.E., M.I.Mech.E., M.Inst.M.M., F.G.S.
A. Wade, D.Sc., A.R.C.S., F.G.S., M.Inst.M.M., F.Am.G.S.

Honorary Treasurer: Lord Plender of Sundridge, G.B.E.
Solicitors: Messrs. Ashurst, Morris, Crisp & Co.
Auditors: Messrs. Price Waterhouse & Co.

* Deceased.

Bankers:
WESTMINSTER BANK, LIMITED,
21, Lombard Street, London, E.C. 3.

Hon. Editor:
A. E. DUNSTAN, D.Sc., F.I.C., F.C.S.

Hon. Librarian:
A. WADE, D.Sc., A.R.C.S., F.G.S., M.Inst.M.M., F.Am.G.S.

Associate Editor, Librarian and Secretary, Standardization Committee
GEORGE SELL.

Hon. Secretary:
ARTHUR W. EASTLAKE, M.I.Min.E., A.M.I.Mech.E.

Secretary:
S. J. ASTBURY, M.A. A.M.Inst.C.E.

Offices—Aldine House, Bedford Street, Strand, London, W.C.2.
Telegrams: Instpetech, Lesquare, London.
Telephone: Temple Bar 1842.

CONTENTS.

	PAGE
Council Officers	i–ii
General Notices	v–vi
Special Notices and Personal Notes	iv–vii
Some Notes on the Holley-Mott Continuous Counter-Current Washery, as applied to Petroleum Products. By E. THORNTON, B.Sc., A.I.C. ..	957
Trinidad Branch: Technical Records for Use on an Oilfield (Trinidad). By J. L. HARRIS, M.C., B.Sc., A.R.S.M., A.R.C.Sc.	971
Some Notes on the Mixing and Placing of Cement in Oil Wells. By L. A. BUSHE	1017
Correspondence	1035
Reviews	1039

ABSTRACTS.

PAGE

Class 100. Geographic Occurrence 491A
„ 200. Geology and Origin 493A
„ 300. Development and Production 494A
„ 400. Transportation, Storage and Distribution 497A
„ 500. Properties and Their Determination 499A
„ 600. Refining and Refineries 511A
„ 700. Utilisation 523A

AUTHOR INDEX.

The numbers refer to the Abstract Number.

Albin, T. C., 1310
Allen, H. D., 1253
Alther, J. G., 1277
Augstadt, H. F., 1284

Barr, G., 1254
Barton, D. C., 1206
Bataafsche Petroleum Mij., 1280, 1286, 1287
Bauer, A. D., 1252
Berwald, W. B., 1242
Bignell, L. G. E., 1214, 1224
Bobdanowicz, C., 1203
Britton, S. C., 1300
Brooks, D. C., 1226
Brown, J. W., 1281

Chapman, M. E., 1219
Choppin, A. R., 1236
Cockrane, E. W., 1257
Coleman, S. P., 1277
Conine, R. C., 1220
Clark, E. M., 1279
Clayden, A. L., 1302
Cloer, V. U., 1277
Cremer, W., 1262

Dehn, F. B., 1284
Delattre-Seguy, J., 1277
Dittrich, E., 1276
Dubrisay, R., 1248
Duda, O., 1212
Du Pont de Nemours, 1286
D'Yarmett, E. C., 1287

Edeleanu Gesellschaft, 1283
Edgar, G., 1245
Egloff, G., 1277
Erickson, C. L., 1287
Evans, U. R., 1300
Eymann, W., 1255

Ferris, S. W., 1286
Filhol, J., 1199
Fischer, F., 1262
Fisher, H. F., 1222
Flood, D. T., 1245
Ford, C. S., 1252
Foster Wheeler, Ltd., 1287
Fox, C. E., 1283
Freund M., 1249
Fulweiler, W. H., 1246
Funk, I. B., 1273

Gaede, — 1295
Gard, C. D., 1287
Gardner, F. T., 1237
Gary, W. W., 1281
Gaus, W., 1279
Gayer, F. H., 1232
Germann, F. E. E., 1233
Gohr, E. J., 1279
Gomory, W. L., 1279
Grahame, J. H., 1281
Graves, W. H., 1301
Grisard, M., 1271
Gruse W. A., 1305
Gulf Refining Co., 1281
Guthke, F. W., 1279

Hall, F. W., 1281
Herbeman, A. M., 1222
Hickman, R. D. C., 1283
Hladky, J. W., 1245
Hoeman, E. C., 1244
Hofmann, F., 1283
Hopkins, G. R., 1257
Hubner, W. H., 1229

Ipatieff, V., 1235

Jennings, J. M., 1279
Johnson, C. M., 1259
Johnson, J. W., 1285
Johnson, J. Y., 1286
Johnson, T. W., 1242
Jones, G. W., 1241
Jones, L. D., 1283
Jordan, C. W., 1246

Kennedy, R. E., 1241
Kimball, L. B., 1281
King, R. H., 1284
Knight, O. S., 1233
Krauch, C., 1279

Lawson, C. W., 1290
Leamon, W. G., 1287
Lederer, E. R., 1251
Lee, F. W., 1293
Lerer, M., 1234
Levine, I. M., 1235
Levorsen, A. I., 1207
Logan, K. H., 1223

McBride, R. S., 1288
Mallison, H., 1239
Manley, R. E., 1283
Menville, R. L., 1236
Meyer, P., 1260
Mills, B., 1210, 1213
Miller, M. B., 1267
Morrell, J. C., 1281
Mueller-Conradi, M., 1283
Murphy, G. B., 1229, 1238

Nelson, E. W., 1250
Nutt, A., 1303

Obersteider, J. L., 1240

Patterson, T. R., 1294
Peck, E. B., 1277, 1279
Peterkin, A. G., 1283
Peters, K., 1262
Pier, M., 1279
Pogue, J. E., 1198
Pyhala, E., 1231

Radjy, A. H. K., 1216
Radulesco, G., 1243
Reymond, W. P., 1274
Rhodes, E. H., 1253
Rhodin, J. G. A., 1256
Ribagnac, 1228
Riedel, W., 1297
Ritchie, K. C., 1264
Rosier, C. A., 1280
Rowling, A. M., 1225

Schneider, E., 1299
Shaw, H., 1291
Sherwood, S. N., 1282
Sieber, W. C., 1304
Sims, W. F., 1277
Skinner, E. F. ,1287
Smith, A. D., 1277
Smith, L. B., 1283
Soc. Rech. et d'Expl. Petr., 1280
Standard Oil Dev. Co., 1278
Staniland, G., 1293
Stratford, W. M., 1277
Stuart, M., 1281
Sunder, R., 1258
Sviland, J. T., 1205
Swindell, F., 1217

Teodorovitch, V. P., 1235
Thamm, S., 1249
Thomas, H., 1281
Tookey, W. A., 1289
Trescott, L. C., 1265
Truesdell, R., 1270
Try, A., 1281
Typke, K., 1230

Uren, L. C., 1204

Vandenberg, G., 1261
Vellinger, E., 1243

Walter, C. M., 1292
Ward, A. L., 1246
Weaver ,J. B., 1281
Waterman, H. I., 1279
Watson, C. W., 1277
Weber, H. C., 1281, 1297
Werner, R., 1283
Whatmough, W. A., 1247
White, F. C., 1282
Wichert, P., 1298
Wilson, C. C., 1209
Winkler, K., 1279
Wirth, C., 1238
Wood, C. E., 1216
Woodman, R. M., 1307, 1308
Woolnough, W. G., 1298
Wulff, C., 1283

Young, A., 1200

Zublin, E. W., 1251, 1266

BACK NUMBERS OF THE JOURNAL.

The Institution is desirous of purchasing a limited number of clean copies of Journal No. 35, February, 1923, and of Journal No. 67, April, 1928. The price which will be paid for such copies is 7s. 6d., and all inquiries should be sent to the Secretary.

CORRESPONDENCE.

Although the columns of the Journal of the Institution are open for correspondence, comparatively little use has been made of this facility in the past. The Council feel that more extensive use might be made of this by members who wish to record briefly matters of interest, experiences with regard to technical problems or difficulties, or to obtain information on some particular technical subject. In this way home and foreign members would be kept more in touch with each other and with technical matters of current interest, and it is hoped that a more general use will be made of the Journal.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

NOTICES.

The Institution as a body is not responsible for the statements of opinion expressed in any of its publications.

Copyright. Authors of papers and articles are requested to transfer their copyright to the Institution for a period of six months from the date of receipt of the paper. Such transfer should be made in writing when the manuscript is forwarded to the Editor.

Editors are permitted to publish abstracts, providing that acknowledgment is made to The Institution of Petroleum Technologists.

Issue of Journal. The Journal is issued in twelve parts per volume, commencing in January of each year.

Members whose subscription is not in arrear receive the Journal free of cost, and additional copies are charged at the rate of 7s. 6d. per part, unless otherwise stated. A member whose subscription is not paid by March 31st of the year for which it is due is considered to be in arrear.

Changes of Address. Members are requested to notify any change of address to the Secretary.

Papers and Articles. Members are invited to submit papers to be read at the General Meetings of the Institution, and are specially asked to forward articles for consideration for publication in the Journal. Diagrams, illustrations, etc., should be suitable for direct photographic reproduction. Authors are informed that all papers, whether for reading or for publication, will be submitted to a referee nominated by the Publication Committee.

Authors of papers published in the Journal are entitled to receive 25 free reprints of their contribution. Further copies may be obtained on payment, and orders for these should be sent to the Secretary when the manuscript is forwarded to the Editor. The free reprints do not include any discussion which may be published with the paper, but authors may have such discussion included in their reprints on payment of the additional cost.

Galley proofs of the paper to be read at a General Meeting are available at the time of the meeting, but members desirous of receiving such galley proofs in advance should apply to the Secretary.

Binding of Journals. Members desiring to have their Journals bound in cases should send them, together with a remittance of 5s. 6d. per volume, to Messrs. Speaight & Sons, Ltd., 98, Fetter Lane, London, E.C. 4. A charge of 7s. 6d. will be made for binding Vol. 10, 1924. Remittance in all cases must accompany the order.

Abstracts. Abstracts of the more important articles and patent specifications are published with each issue of the Journal, this supplement being paged independently of the transactions. Members and Journal Subscribers desiring to have the Abstracts printed on one side of the paper only can be supplied with these at a charge of 10s. per annum per copy, payable in advance.

Medals. The Redwood Medal is awarded, at the discretion of the Council, as and when desirable, but not more than once each year, to a petroleum technologist of outstanding eminence, irrespective of nationality or membership of the Institution.

A medal and a prize of five guineas is awarded annually by the Council to that Student Member of the Institution who shall, in their opinion, have presented the best paper during the session.

Benevolent Fund. The Benevolent Fund is intended to aid necessitous persons who are or have been members of the Institution, and their dependent relatives.

The Fund is raised by voluntary annual subscriptions, donations, and bequests, and all contributions should be sent to the Secretary of the Institution at Aldine House, Bedford Street, London, W.C. 2. The Fund is administered by the Council through the Benevolent Fund Committee, and all applications in connection therewith must be made on a special form which can be obtained from the Secretary of the Institution.

Appointments Register. A register of members requiring appointments is kept at the offices of the Institution, and every effort is made to assist members of the Institution in search of employment.

Members who desire their names and qualifications to be included in this register are requested to apply to the Secretary for the Form of Application for Registration, if they have not already done so. Members residing in the London area are asked, if possible, to return this Form in person and make themselves known, together with their requirements, to the Secretary. It is also requested that members should notify the Secretary immediately they have obtained an appointment.

In submitting names of candidates to prospective employers it is understood that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library may be consulted between the hours of 10 a.m. and 5.30 p.m. daily. (Saturdays, 10 a.m. to 12 noon.)

Advertisements. Advertisements are inserted in the Journal, and information as to terms, etc., can be obtained from the Advertising Manager, at the offices of the Institution, Aldine House, Bedford Street, W.C. 2. (Telephone No. Temple Bar 1842.)

Prepaid small advertisements, such as situations vacant and wanted, patents for sale and miscellaneous, are accepted at a charge of 1s. per line of seven words (minimum 4s.). Box number 1s. extra. These should be sent to the Associate Editor not later than the 12th of the month in which it is desired they should appear.

LIST OF ADVERTISERS.

Members are desired when making enquiries or placing orders with advertisers to mention that they have seen their announcement in the Journal.

W. Christie & Grey, Ltd.
A. F. Craig & Co., Ltd.
Duke & Ockenden, Ltd.
W. Edwards & Co.
Hadfields, Ltd.
Hayward-Tyler & Co., Ltd.
Lewis & Tylor, Ltd.
National Supply Corporation
Oil Well Supply Co.
John G. Stein & Co., Ltd.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that members send information regarding their movements to the Secretary, for insertion under this heading.

Mr R. H. Ames is returning to the United States.

Dr. J. A. L. Henderson is returning home from Canada.

Dr. H. G. Kugler has left Switzerland and is now in Trinidad.

Mr. V. Laycock has returned to Persia.

Mr. Albert Millar has returned from Poland, and is leaving for Burma.

Mr. G. E. Owles is returning from Peru early in the New Year.

Mr. D. J. Pull is home from Persia.

The Secretary would be glad to learn of the whereabouts of the following members: E. E. G. Agius, J. M. Brown, E. J. S. Hewitt, J. Jawad Jafar, G. D. Jardine, A. MacLean, T. Speight, R. W. Stiles and E. K. Wallen.

NOMINATIONS FOR MEMBERSHIP OF THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

The following have been nominated for membership of the Institution of Petroleum Technologists and their Application Forms may be seen at the Offices of the Institution :—

As Members.	*Proposed by*	*Seconded by*
PARSONS, Roy George, Manager, Colonial Gas Association, Ltd., Footscray, Victoria, Australia	J. E. Hackford	H. K. Hiller
PRISTON, Harold Edward Mead, Chemist, 74, Parkside Way, North Harrow, Middlesex	J. S. Jackson	H. C. Reynard
SCHLUMBERGER, Conrad, President, 30, Rue Fabert, Paris VII., France ..	P. de Chambrier	L. Wenger
VINEALL, George John Charles, Chemist, 93, Amberwood Rise, New Malden, Surrey	J. S. Jackson	H. C. Reynard
As Associate Members.		
DOCKSEY, Patrick, Chemist, 6, Sidney Road, Staines, Middlesex	F. B. Thole	R. Pitkethly
HILLS, Sydney Robert, Chemist, 22, Woodland Rise, Greenford, Middlesex	J. S. Jackson	H. C. Reynard
As Transfer to Associate Member.		
BLACKSTONE, Stanley Ernest, Engineer, c/o E. E. Blackstone, Esq., Aldwych House, Aldwych, London, W.C.2. ..	R. G. Stickland	J. S. Jackson
As Student.		
LINDSAY, John Alexander, Student, 135, Parkdale Road, Plumstead, London, S.E.18	C. H. Lander	

LIBRARY.

The following additions have been made to the Library since November 1, 1933 :—

BOSWELL, P. G. H. On the Mineralogy of Sedimentary Rocks.

BRITISH STANDARDS INSTITUTION. B.S.S. 504–1933. Drawn Lead Traps.

—— B.S.S. 505–1933. Road Traffic Control (Electric) Light Signals.

FUEL RESEARCH BOARD. Report for Year ended March 31st, 1933.

HEILAND, C. A. Elements of Geophysical Prospecting.

HEILAND, C. A. Uber die seismische Reflexiousmethode.

NICOLESCO, C.-P. Gisements Petroliferes de L'Irak.

U.S. GEOLOGICAL SURVEY. Bull. 845. Guidebook of the Western United. States. Part F. Southern Pacific Lines. N. H. Darton.

—— Circular 3. The Bleaching Clays. P. G. Nutting.

—— Circular 4. Some Deposits of Ornamental Stone in Montana. G. R. Mansfield.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE ONE HUNDRED AND FIFTY-SECOND GENERAL MEETING of the Institution of Petroleum Technologists was held at the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, November 14th, 1933, Mr. T. DEWHURST (President), occupying the Chair.

The **Secretary** read the names of candidates nominated for election, and the following list of members elected :—

As Members.—Vezio Cambi, John James Leggati Hamilton, John Augustus Oriel.

As Associate Members.—Victor Jevanoff, John Basil Robinson, Archibald Winterbottom.

As Transfer to Associate Member.—Leonard Charles Stevens.

As Student.—Eric Bruce Sangster.

The **President,** in introducing Mr. Thornton, said that he was no stranger to the Institution, for he had been an Associate Member since 1922 and had been Hon. Secretary and Treasurer of the Welsh Branch of the Institution since its formation. He understood that Mr. Thornton's contribution to the discussion of a paper at the World Petroleum Congress was considered to be so interesting and valuable that he was pressed to expand it and present it to the Institution in the form of a paper. He had no doubt that the subject was very interesting and important.

Some Notes on the Holley-Mott Continuous Counter-Current Washery as Applied to Petroleum Products.

By E. THORNTON, B.Sc., A.I.C. (Associate Member).

IT would be a very difficult task to propound anything really novel or original about petroleum treatments as such to-day. There is, of course, no dearth of literature putting forward the various ideas that are already in vogue dealing with new solvents or reagents and plants for applying the various processes, but they are not really novel in principle. To take the well-known treatment of cracked spirit with sulphuric acid as an instance, this could scarcely be called new, yet there are difficulties in the application of this process which were the subject of papers at the World Petroleum Congress. A paper by Halloran suggested the control of this treatment by extraordinary cooling and another by Egloff suggested the abolition of this treatment and the substitution of the use of inhibitors.

Tens of thousands of tons of cracked spirit have been treated by means of acid, and it seems worth while, therefore, to make known the principles underlying the plant which has helped to

achieve this success. No attempt is made to claim that there is anything miraculous or likely to revolutionise the oil industry, but the Holley-Mott Continuous Counter-Current Washery has been applied with good results to the treatment of spirits, kerosines and lubricating oils with such varying reagents as sulphuric acid, calcium hypochlorite solution, sodium hydroxide solution and lime water on the large scale, and on the small scale for solvent extracts with reagents like sulphur dioxide.

It is the object of this paper to show that its usefulness lies in the application of sound principles in a very convenient way.

General Principles of Treating Plants.

Before describing in detail the particular plant under discussion, it has been considered worth while to set out what in the opinion of the author are the principles guiding the design and use of treating plants in general; there are three outstanding points which are almost too obvious to require statement but which nevertheless have been met in a multitude of different ways in different plants.

A good plant must :—

(1) Mix reagent and treated material to give the desired intimacy of contact.

(2) Maintain this desired intimacy of contact for a controlled time.

(3) Separate reagent and treated material effectively when this time has expired.

In addition to these three major requirements it is often desirable, though not essential, with a good treatment plant that the following things should be possible :—

(4) To cause the reagents used to flow in a true counter-current manner to the liquid being treated.

(5) To use sufficient stages to exhaust the reagent completely.

(6) To vary the proportions of the two liquids during admixture, irrespective of the amount of the nett reagent actually consumed.

(7) To transfer from one stage to another the correct amount of the two liquids easily and simply.

(8) To maintain such internal stocks of the reagent as will prevent the bad effect of momentary variations of feed from being reflected in the quality of the finished product.

(9) To control the temperature of reaction easily at all stages.

(10) To be reasonably free from break-down and as automatic as possible in operation.

Application of Principles.

1. *The making of an intimate mixture containing suitable proportions of liquid to be treated and desired reagent.*—The choice of

methods of mixing is quite large, from the very intimate dispersions obtainable by means of air jets or some sort of colloid mill to the loose and inefficient contact achieved by pumping through pipes with bends. Circumstances and the relation between cost and efficiency desired decide which of these is chosen in most refineries. The author considers that for all-round economy with low maintenance cost, the vessel containing a suspended stirrer revolving at a moderate speed with no footstep bearings is the most satisfactory, and this is the principle adopted in the Holley-Mott plant. Devices requiring high pressure or high speed in the long run require more maintenance and are more difficult to keep under satisfactory control than such a simple stirred vessel, whilst any form of pump usually has glands covered with liquid which are a source of leakage and nuisance.

2. *Maintenance of contact time.*—Unless an emulsion is to be made, kept for a standard time and broken at will, contact time is usually controlled by the size of vessel in relation to throughput in the case of a continuous plant; this is the principle adopted in the Holley-Mott plant.

3. *Separation.*—The problem of separation depends very largely on the method adopted for mixing. If violent agitation or stable emulsification has been adopted, then it may be necessary to use high efficiency methods, such as centrifuging, to get separation. Various arrangements of baffles in tanks are also put forward from time to time, but it is the author's opinion that the simplest and cheapest is the use of gravity-settling in a plain tank wherever possible. In the Holley-Mott plant the degree of mixing is kept under control to enable separation by gravity to take place in reasonably sized vessels.

4. *Counter-currency.*—Counter-currency can be achieved by pumping the liquids through a series of vessels, but in the plant described the lay-out is such that the flow takes place easily and naturally by gravity alone through vessels which are built all on a level.

5. *Exhaustion of reagents.*—Almost any number of stages can be placed in series without difficulty and with no extra pumps.

6. *Variation in proportion of liquids mixed.*—It frequently happens in petroleum refining that treatment is required by an extremely small quantity of reagents; in particular a kerosine may have to be treated with 0·25% by volume of oleum. A uniform dispersion of so small a quantity of reagent throughout so large a quantity of oil can be achieved only by fairly drastic mixing. If, however, the new acid is mixed with spent tar, it is possible to disperse the solution of new acid in tar much more easily through

an amount of oil of the order of five times its volume. This result can be achieved in any counter-current plant by a suitable arrangement of suction lines to the pumps or mixers, and is arranged with extreme ease in the Holley-Mott plant because of the natural circulations which take place between vessels.

7. *Transfer of correct amounts.*—The transfer of correct amounts also takes place quite easily since the overflow is automatic in the Holley-Mott plant. A change in throughput usually means no more than the altering of the feed valves for chemical and oil.

8. *Maintenance of reagent stocks.*—This is quite an important point in a washery which is continuous, since it is not always true that over and under treatments will balance out. If a single stage of short time intimate mixing is adopted the slightest irregularity in feed of the reagent allows some portion of the material being treated to get through untreated. The Holley-Mott plant, having several vessels containing a reasonably large quantity of reagent in various stages of activity, is independent of small irregularities in the supply of reagents.

9. *Control of temperature.*—Where any heat of reaction is evolved, or where the desired reactions take place within a limited temperature range, it is desirable to be able to control the temperature at will ; this is achieved in the Holley-Mott plant by the insertion of coils for the supply of steam or water, as needed.

10. *Continuity of operation—automatic control.*—The plants in use have worked for periods of three and four years without having to be cleaned out or be stopped except at will.

Operation is so nearly automatic that one man only is required to operate and keep clean a large plant dealing with over a thousand tons per 24-hour day.

Details of the Holley-Mott Plant.

(*a*) *The unique principle.*—Consider a vessel of the shape illustrated in the diagram 2A. If such a vessel is half filled with a heavy liquid having a specific gravity of, say 2·0, and then the top half is filled with a light liquid having a specific gravity of 1·0, it is obvious that we have three distinct " U " tubes, which are exactly balanced and the liquids are at rest.

Now consider as in case (*b*), that we introduce a stirrer into the right-hand vessel, a mixture will result, and if the quantities are equal the resulting specific gravity will be 1½. Under these conditions, in the upper half of the vessel, above the line " XY " the liquid in the agitator will be heavier than the liquid in the separator and a flow of mixture from agitator to separator will result through the centre tube, tending to restore hydrostatic equilibrium above

the line "XY." The upper tube, however, allows liquid to flow from the separator to the agitator so that a circulation is produced.

Similarly in the lower half of the vessel the liquid in the separator will be heavier than the liquid in the agitator and a flow of heavy liquid will take place from separator to agitator in the bottom tube, and a flow of mixture from separator to agitator in the centre tube. It will, therefore, be seen that a continued circulation of mixture from the agitator to the separator will take place through the centre tube, and a flow of separated light and heavy liquid from the separator into the agitator through the upper and lower tubes respectively.

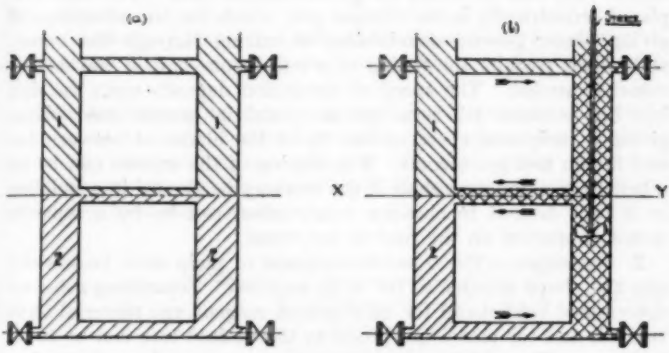


DIAGRAM 2A.

If now we introduce into the agitator a flow of fresh product and chemical it will be possible to remove from the separator light liquid and heavy liquid, and these can be taken wherever required.

It will be realised that we have here in a single pair of vessels a mixture, a separation and a flow, induced by the rotation of a single stirrer in one of a suitably designed pair of vessels.

Reference to diagram 2c shows how the connecting up of a series of pairs of vessels gives in addition counter-currency of flow and in fact a washery embodying most of the good points outlined in the foregoing remarks on general principles. Since over-flow from vessel to vessel is entirely dependent on the introduction of new material it is necessarily, throughout the plant, exactly proportioned to the amount of new material entering, both of material to be treated or of reagent. Furthermore, a study of the diagram will illustrate how the proportions of reagent and material treated can be maintained at any desired ratio in each single pair of pots by

weir adjustment, quite independently of the nett amount of reagent entering the system.

(*b*) *Detailed application.*—1. *Mixers.* As indicated when discussing the general principles, a plain stirrer in a vessel of suitable size is used for obtaining the desired degree and time of mixing.

The design of the stirrer consists of three plain diamond blades set at angles of 120° to each other along the length of a plain steel shaft; this shaft is suspended and turns through the roof of the vessel without contact, a seal being made by the fitting of an inverted cap working in an annular shaped seal vessel which contains oil. Where the plant is without a covering building a double seal can be fitted to guard against rain. The stirrer is placed eccentrically in the circular pot, which has the advantage of giving better general distribution of mixing through the vessel, and which permits the fitting of a coil in one-half of the mixing vessel if needed. The speed of revolution depends upon the size, but lies between 1-3 revs. per sec., and in normal-sized plants giving a peripheral speed at the tip of the blades of between ten and fifteen feet per second. The driving of the stirrers can be by a belt from a common shaft if the washery be housed in a building or if it is desired to cheapen construction can be by a separate motor supported on the roof of the vessel.

2. *Separators.*—The separators consist of plain steel vessels of a size and shape suitable to the work required. Separating rates are determined beforehand for mixtures of reagent and material to be treated, and for petroleum products the desired rate can be taken as between 50 and 200 gallons per hour per square foot of interface area, depending on the oil and the reagent used.

Vertical cylindrical, horizontal cylindrical and rectangular cross section tanks have each been used as separators in different units.

Separators which have to deal with weak sulphuric acid are lead lined and in special cases have been made of wood.

3. *Corrosion.*—Corrosion can be dealt with by making parts of special metals. Stainless steel shafts with welded blades, the whole being metallised with lead, have given very long service.

4. *Weir.*—The flow is regulated by an adjustable weir of a very simple pattern.

5. *Chemical feeds.*—Chemical feeds are measured in the normal manner by an orifice meter, with the exception of acid which is best measured by dip in an overhead tank, a balance float being found more accurate and less dangerous than the continued insertion of rods.

6. *Skimming.*—It was anticipated in the early days that trouble might be experienced from the accumulation of interfacial layers

of emulsion or other matter and skimming devices were fitted to deal with this; in fact they have been used very seldom.

Application.

Sweetening of benzine.—The following indicates the lay-out of plant for this purpose.

(*a*) There is one pot devoted to the counter-current extraction of residual H_2S and light mercaptans, by means of 0·04N lime water remaining after hypochlorite is spent.

(*b*) There are two pots devoted to controlled oxidation to disulphide by means of hypochlorite of controlled strength and alkalinity.

(*c*) There are eight pots giving a final de-acidification with lime water.

Acid treatment followed by distillation and sweetening (see diagram).—There are five pots giving counter-current acid treatment with F.O.V.

There are three pots giving a neutralising treatment (of lime).

There is a steam distillation tower from which the distillate enters the last section, consisting of two pots, giving the exact chemical amount of weak hypochlorite of correct strength and one pot giving lime water wash.

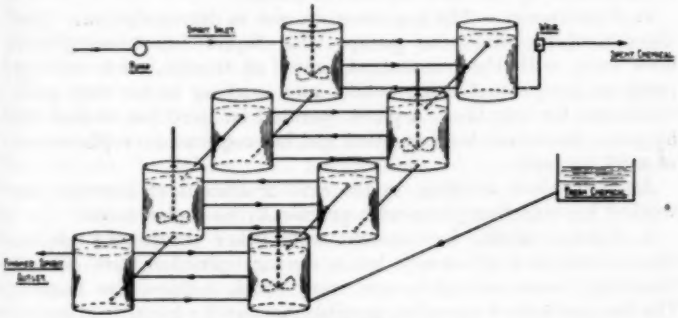


Diagram 2c.

Note on Operation.

It has been found on a number of occasions that the bodies formed by acid treatment of kerosines and spirits tend to neutralise into soaps, giving persistent emulsions in the alkali washing stages; this can be overcome by regulating the supply of alkali to be insufficient to neutralise the spent liquor; by this means the bulk of the sulphonates, etc., which would tend to form soaps are washed out in neutral or slightly acid solutions before the remaining

oil soluble pseudo acids meet the neutralising alkali in the later stages.

In this connection it is interesting to note that extremely dilute reagents can be used in a plant of this description.

Summary of Advantages.

The advantages claimed by the type of plant described may be summarised as follows :—

1. *Cost.*—As a counter-current continuous plant it has the usual advantages of such a plant over batch operation, and where the throughput warrants the installation of such a plant, the cost of the Holley-Mott plant compares favourably with that of any alternative design, using pumps, orifices, etc.

2. *Operation.*—The usual advantages of counter-current continuous plants in the saving of chemical are achieved.

In addition the very compact form and semi-automatic character of operation make for extreme simplicity of control and low labour cost.

One man operates and keeps clean a plant capable of dealing with well over 2000 tons of spirit per 24-hour day, and there should be no hesitation in building a plant of double this capacity to be worked by the same amount of labour.

3. *Maintenance.*—The maintenance cost is extremely low. The absence of multitudinous pumps with liquid immersed glands does away with the commonest source of trouble, such moving parts as are present being robust and working under very good conditions for long life. A plant operated on spirit has worked for 5½ years, has never been emptied and has required no replacement of working parts.

Another plant working on the acid treatment of kerosine has worked for over four years with practically no replacement.

4. *Safety.*—Again, in common with other continuous plants, the maintenance of steady levels during operation cuts out all breathing losses on spirits and very much reduces fire hazard. The long periods of operation possible cut out the hazards attended by the continual filling and emptying of the plant for repair reasons.

DISCUSSION.

The President said that every member and guest present would agree that they had listened to a very interesting paper. He was much impressed with the extreme simplicity, ingenuity and efficiency of the Holley-Mott continuous counter-current washery. However, they did not require the appreciation of a layman, but the most expert appraisal and criticism of the paper, and therefore he would call on Mr. Mitchell to open the discussion.

Mr. W. C. Mitchell said that Mr. Thornton's paper had really put on record details of the operation of a plant which his company, the Anglo-Persian Oil Company, had found very effective and efficient, as it was felt that notes on the operation of this plant would be useful to other people as well.

The three great points about this plant which appealed to his company and to himself personally were its simplicity, its adaptability and its economy. Its simplicity was obvious. It was nothing more or less than a reasonably constructed mixer with a reasonable separator, coupled with an adaptation of the principle of differential gravity to cause continuous flow through the series of tanks to give a continuous counter-current plant. It was this simplicity which made the plant so useful and flexible. Dealing with its adaptability, the putting down of a plant of this kind for any particular purpose did not mean that its use was limited to that purpose, but it could be modified and used to meet the conditions of other treatments. It was particularly useful in cases in which one employed a very small proportion of reagent, particularly an acid. The fact that one could use 0·25 per cent. of acid efficiently, effectively and exhaustively was a very important point, and, moreover, a point which it was difficult to achieve in most of the other types of washery of which he was aware. This plant also could be used for many different products, from the lightest spirit down to the heaviest lubricating oils, or even bitumen, as had been done by his company.

The economy of the plant was really the point which appealed most to him and which had been of most use to the refinery. It represented an economy not only in the utilisation of chemicals, but also in the labour and maintenance of the plant. These were points on which Mr. Thornton had dwelt, but he would like to add that it was really a very important factor that one could operate a plant to deal with 20,000 gallons per hour with less than one man employed—that is to say, the man engaged in the actual operation could also look after the plant and clean it. The cost of maintenance was practically nil, and the fact that one could use small or large percentages of reagents and effectively exhaust them was in itself a very important factor in economic operation.

Dr. A. E. Dunstan said that he felt the members present would be disposed to thank Mr. Thornton very much for the extraordinarily lucid way in which he had described this Holley-Mott washery and for Mr. Docksey's demonstration. The speaker's own knowledge of this system went back for the best part of eighteen years, when Messrs. Holley and Mott were at Oldbury engaged in the particularly arduous job of making T.N.T. The first unit constructed was in fact designed as a continuous plant

for the manufacture of T.N.T. He (the speaker) had had the opportunity of seeing the plant at work at that time on a scale that was really considerable. It was a most impressive sight to see the liquid T.N.T. flowing down in a constant uninterrupted stream. Some years later Dr. Mott joined his staff, and it occurred to him that the Holley-Mott process might form the basis of a method for the refining of petroleum distillates. Dr. Mott put up a little model twelve or thirteen years ago. In those days—and it is rather interesting to let one's recollections go back to so short a period as twelve years ago—there was not much thought about continuity of operation. The industry was then in the happy position of not having to worry over-much about economies, and it was not until a considerable time afterwards that the Holley-Mott plant came into existence as a plant for refining petroleum products.

The names Holley and Mott were combined in the title of the plant, but he would be inclined to add the names of two others, Messrs. Mitchell and Thornton, and to give it a quadruple name, because, after all, there had been an immense amount of development and improvement in all directions applied to this extraordinarily beautiful original conception of using the energy of rotation as a means of translation, and that was, of course, after all, what the plant amounted to.

Mr. Thornton had told the meeting about the efficiency of the plant, and to that he need not add anything. But it did strike him as a very elastic plant. There was no operation involving mixing and contacting and chemical reaction of two liquids that this plant could not efficiently undertake. It must be realised that to-day they were just on the eve of outstanding developments in the manufacture of lubricating oils by solvent extraction, and the Holley-Mott plant offered an ideal apparatus for this work.

Mr. J. E. Hackford said that there were one or two questions to which he could not quite see the answer. From the diagrams of the plant which had been shown it appeared to him that there must be a relatively large bulk of washing material, whether it be acid, soda, or anything else, in the stirrer at one time. It was mentioned that this plant had been used for cracked spirits, and one of the main features one had to look to in the treatment of cracked spirits was that not only should the acid be of small quantity but be actually in contact with the cracked spirit for a minimum period of time. In this plant it appeared to him that if only 0·25 per cent. was actually used, the dead weight or the bulk of acid that came into contact with any part of the gasoline at one moment must be extremely large. He thought, therefore, it would be difficult for this to be successfully used with regard to cracked vapour-phase spirit. He was aware that some cracked spirits

were made by Mr. Thornton's firm, and it would be interesting to know what its experience of this matter was.

Dr. F. H. Garner raised a question in regard to the statement made by the Author that in particular a kerosine may have to be treated with 0·25 per cent. by volume of oleum, and that in such case the oleum was thinned down with acid tar. It would appear that some amplification of this statement would be helpful, since the action of oleum may be quite different from that of the same proportion of sulphuric acid in a lower concentration, the more concentrated acid attacking hydrocarbons of the aromatic or naphthenic type.

Mr. E. S. Hillman said that there were several points in connection with this apparatus which, it occurred to him, might be of some difficulty in practice, but before dealing with those points he wished first of all to say that it was very pleasant to see in operation in these days a flexible plant made up of units which were fairly reasonable in size. The tendency was to go in for extreme efficiency and for what he would call extreme instability, so that very often one could get a paper efficiency which the engineer—he was himself speaking as an operating chemist, and so as one much more interested in operating efficiency than in compact design or what might be called volumetric efficiency—would consider a very fine development theoretically. The man who had to work the plant, however, with such an unstable unit, never knew when he would not have to be running here and there to check instability, possibly even with the fear of the refinery catching fire if he failed. Therefore this particular unit struck him as very good from the operating point of view as regards stability.

He had found that certain kerosines were extremely sensitive to the length of contact in the presence of acids. In fact, he had operated a type of continuous plant which at first delivered a very good kerosine—a kerosine of good colour, which was quite stable—but after the plant had been operated for some length of time and waste acid was circulating in it, it began to "go off." He could not help thinking that some kerosines in this type of apparatus would show the same defect, and it would be interesting to know whether the author had had any experience of this trouble, and whether, if so, he had found any means of getting over it. It was very easy to criticise a plant when one had not operated it, but he knew that it was extraordinary what devices the man in charge could employ for getting over these difficulties.

Another point which struck him as being a little difficult was that while the time of contact could, of course, be reduced by the rate of feed through the plant, there must come certain conditions in which one had to get the time of contact in relation to the time

of settling, which could only be done by having the size of the stirring vessel in correct relation to the size of the settling vessel. For example, one might wish to change one's programme from one in which a large mixing vessel was required to one in which a small mixing vessel was necessary. In all the refining works of which he had had experience the programmes were changed so frequently that he would feel that what he wanted was a series of different sizes of agitators, say three, attached to each settling tank. That, at any rate, would be his feeling if he had charge of a plant of that kind, and, of course, it would have the result of piling up the expense very greatly.

Dr. F. Sager said that there were a few questions to ask as regards the acid treatment of cracked distillates. What was the content of the free acid in the reaction mixture or sludge used for the refining of cracked distillates? He also desired to know what the observations were with regard to the speed of polymerisation of the olefines and the formation of the oil-soluble neutral sulphuric acid esters in the Holley-Mott process.

He further asked what the criterium was for the reasonable reaction time. He asked these questions specially because of some work which he has carried out on different cracked gasolines with different amounts and concentrations of acid. He had found that even with a 60° Bé. sulphuric acid the speed of polymerisation was considerable, and that he had to limit the total contact time of acid and gasoline to a few seconds in order to stop the reaction at the required point.

Mr. W. Macnab desired to say how much he had been interested in hearing of the application of a plant which when he last saw it was used in the manufacture of T.N.T. The fact that it could be used for such widely different operations as the nitrating of toluene and the washing of the finished product showed a great deal of flexibility. One of the most interesting applications of science, he thought, made during the war was the use of slight differences of specific gravity in the Holley-Mott plant which had worked excellently in all respects. He had no knowledge which would warrant him to answer the various doubts which had been expressed, but as a washing plant and for treatment with liquids he was sure that this plant was capable of very wide application.

Mr. E. Thornton, in replying to the discussion, said that Mr. Hackford had mentioned the point that there had to be a large bulk of washing material. He feared that he could not have made it clear in his opening remarks that one could by manipulating the valves make that proportion anything that one pleased. One could, instead of having the bottom circulating lines open, transfer through the middle lines, and cause the liquid both at

the top and bottom not to go back to its own pots, but to go onwards. The process would be found to settle down to just the proportions which were being used. In fact, it was a strong point of flexibility that one could have in this plant proportions from 1 in 400 down to 2 to 1, if one wanted, by the manipulation of the amount permitted to circulate around instead of getting on with its ordinary pumping job.

The difficulty of treating cracked spirit which required a minimum time had been mentioned. It was rather late in the day to suggest that this plant would not treat cracked spirit after well over one hundred thousand tons had been treated! It did, in fact, treat cracked spirit extremely well. That was a point which was raised in the discussion at the World Petroleum Congress. If one had acid tar and treated cracked spirit with it, and went on treating the tar with more and more spirit, one came to a stage when it ceased to react at all, if the conditions were cold enough. Somewhere between a spent tar that would not act at all and a new acid that acted rather too vigorously, especially if one got it too warm, one had the possibility of making any desired admixture or dilution between those two active and inactive reagents.

A further possibility was to mix a very unreactive spirit with a more reactive spirit, which proved another successful device for limiting the intensity of reaction which usually caused polymerisation troubles. Even fairly intensely cracked spirits, which would give trouble by too much treatment, were treated extremely successfully by small quantities of acid used with a large proportion of spent tar, the temperature being kept down, not below zero, but, say, at ordinary water supply temperature. Hundreds of tons of cracked spirit had been treated in such a plant as this, and, indeed, this was one of the most useful applications.

Dr. Garner had said that there were cases where oleum differed from tar mixture. This was a point he could not confirm or contradict, but he would say that the effect mentioned in regard to variation in proportion of liquids mixed was not so marked as one would have expected. The result of diluting oleum with spent tar was quite different from diluting with water. There was a tendency for the hydroxyl concentration in the neat material to be the deciding factor. If kerosine were treated with a 5-stage counter-current oleum and a 5-stage counter current C.O.V., whatever amount of excess treatment was given one could not get an oleum treatment effect with C.O.V., because it was not the same kind of treatment, but if one were using oleum diluted with tar from oleum treatment, the oleum action did not cease. In one instance especially heavy kerosine was asked for and a light gas oil was treated. All that was done was to open the inlet pot cover and

pour in some gas oil while the treatment with the kerosine was going on, the resulting oil being water-white, i.e., a colour of under 2 Lovibond in 18 in. cell, whereas they had been previously trying vainly to do this in a batch and could not get the colour under 10 Lovibond in 18 in. cell. It was rather interesting to note the way in which the material gave its chemical action, but it did not seem to have the bad effects which were given in the batch.

In reply to Mr. Hillman, as to sensitivity of contact to waste acid, he did not know the kerosine of which the questioner was speaking, but he could say that with his own firm's kerosines, in the old days as Dr. Dunstan would remember, they had had their share of kerosine washing troubles. They could now take a kerosine, which was heavy enough to have a specific-gravity over 0·8, treat that, and produce an oil which nominally burned ten days in a lamp, but which in their own test burned for fifteen months without being touched, except to put in more oil, and without charring the wick !

The point raised about the time of contact and the relation of mixer and separator was quite sound, but actually no instance of difficulty had been met with. The process turned out to be very flexible in that the limit usually came in some other property than the size of the mixers and separators. He had mentioned the separation rates which were forthcoming, varying between 50 and 200 gallons per hour per square foot.

In reply to Dr. Sager he was unable to answer the question about the acidities of the tar. They had tried to make analyses of acid tar, using various methods of extraction, but he thought perhaps the question might be answered by what he had said a moment previously as to the concentration of acid when diluted with spent tar as not being parallel to the concentration of acid diluted with the same amount of water. It seemed to be going on with the specific type of action.

Although it was pointed out that some things had to be treated and the acid then "flicked" out, he would suggest that it was probably a question of rate of reaction under the particular conditions of temperature and concentration which were being used. Their success in treating what seemed to be intractable materials was due to the flexible control of temperature and strength of reagents present in mass concentration. The strength of the reagent as a chemical was unaltered, but the number of units in a given cubic space was subject to any dilution they desired, and that was the secret of the doing of what would otherwise be rather awkward jobs.

A vote of thanks was heartily accorded, and the meeting terminated.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

THE FOURTH ANNUAL GENERAL MEETING of the Trinidad Branch of the Institution of Petroleum Technologists was held at the Apex Club, Fyzabad, on Wednesday, February 24th, 1932, Mr. A. F. Dabell, Branch Chairman, in the Chair.

The following paper was read :—

Technical Records for Use on an Oilfield (Trinidad).

By J. L. HARRIS, M.C., B.Sc., A.R.S.M., A.R.C.Sc. (Member).

INTRODUCTION.

THE following paper on Technical Records as applied to an oilfield is not submitted in a dogmatic spirit, but rather to excite discussion and criticism.

The number and type of records used must vary according to the different conditions prevailing on the various oilfields.

It is felt that a properly designed system of records will ensure better control and therefore secure increased economies.

Such an ideal system must on the one hand cover all the relevant data, yet it should not be cumbersome or complicated on the other hand.

There seems to be no reason why comparative uniformity of practice in record keeping should not be obtained generally.

Such uniform practice would lead to possible comparison of achievements and economies on various fields, which would lead eventually to the identification of the most economical methods of operation.

GENERAL.

It is, and must be, generally admitted that technical records are necessary for the economic operation of oilfields. The adequate and accurate compilation of past results afford the only basis for accurate estimates of future performances.

As underground conditions become more complicated and the position and extent of oil sands more uncertain, so the importance of past records increases. Consequently records in Trinidad are much more vital than they are in the uninterrupted sheet sand conditions of many present operating oilfields. Application of an intricate series of records to such conditions might possibly be wasteful, but at worst could never be so uneconomical as inadequate technical records. The absence of such information leads to extreme uncertainty with regard to production operations and repair jobs, additional hazard in drilling operations, and the

absence of a sufficient degree of accuracy with regard to past and present performances.

High prices which have been obtained for oil in the past made profits almost inevitable no matter what programme was laid down or what procedure followed. Nowadays it is only the minority of programmes that will ensure a profit, and adequate records are the only means of identifying economical procedures. Records in the past were often regarded as not merely a waste of labour, but were looked upon as a retardation of the speed of operation and a source of increased capital and current expenditure. The implications of a policy of unrestricted and often unreasoned activity were not always realised. Technical advice might be unobtained or disregarded in times of prosperity, and possibly voraciously demanded when conditions were adverse. It might not have been generally realised that frequently economic and correct procedures in prosperity tempered adversity to the firms implicated and ensured a constant policy in both good and bad times.

It is proposed to treat the subject of records in a chronological sense, and with this end in view the initial records of an oil company will be discussed.

A. Preliminary Records.

Prior to the buying or leasing of the property to be developed it is probable that some idea of the geological structure is known. The first necessity, however, is a survey of the property and the plotting of the survey on a suitable scale, say 1/2500.

In the past it has been considered unnecessary to show topography, and probably in the initial stages of the development of the field it would be impracticable to produce a topographical survey. It is, however, recommended that a topographical map, scale 1/2500, be completed at the earliest possible moment. The cost of such a survey is not prohibitive, and such expenditure would speedily be recovered as the field was developed.

The extremely irregular nature of the surface in practically all Trinidad oilfields renders considerable savings possible in the initial construction of roads, buildings, etc. The irregular occurrence of the oil sands makes the problem of spacing of necessity always intimately connected with topography.

After initial development of the field a spacing of a certain amount may be decided on, but if such a spacing is applied it is often found that the well sites are more likely than not to fall into most impossible positions. This leads to very considerable expense in the initial location of the wells due to location of roads in bad positions and unnecessary clearing.

From this point of view a topographical map is absolutely indispensable. Theoretical spacing of wells must in the nature of things be subservient to topography when both oil sands and surface are irregular.

If a topographical map is available in the early stages of field development the whole lay out of buildings, roads, reservoirs, etc., can be rigidly laid down with very appreciable economies.

After a plan of the field is obtained a geological map of the surface is the next desideratum. If the surface geology is not plotted on a topographical map the interpretation of such surface geology is difficult and the map misleading in those areas where the topography is irregular.

A further advantage of a topographical map is that it materially minimises the necessity for the services of a surveyor for ascertaining level of wells and locations of positions generally on the field.

Records of Underground Development (Sections and Well Logs).

In addition to the maps described above the following records are recommended to be kept :—

B.1 Strip logs (indicating formation, oil, water and gas shows, etc.).

It is suggested that these logs be kept on squared paper and compiled concurrently with information obtained from the daily or tour drilling logs, and that the scale for these logs be 1 in. = 100 ft. One square = 10 ft.

B. 2. A graphic log be made up from the strip log for permanent record, and be sufficiently large to incorporate dates, separate casing logs and well histories. In the event of a well being deepened, there should be sufficient room to insert the new casing log and add the further history of the well. The size which the writer favours is 18 in. x 28 in., and it is recommended that, for easy individual withdrawal and replacement, these logs should be suitably mounted with slotted cardboard hangers and kept in racks.

B. 3. Sections incorporating the information on the strip log, and corresponding to the scale in use for survey of the field, are also recommended for use.

A log for the graphic representations of formation, shows, casing, etc., is submitted, as well as a portion of a type section. (See Figs. 1 and 2.)

[Note.—The strip logs for current wells might be attached to pieces of light wood and be hung from nails in the wall for ready reference.]

Underground Contour Maps.

Maps of this nature should be constructed for main producing horizons.

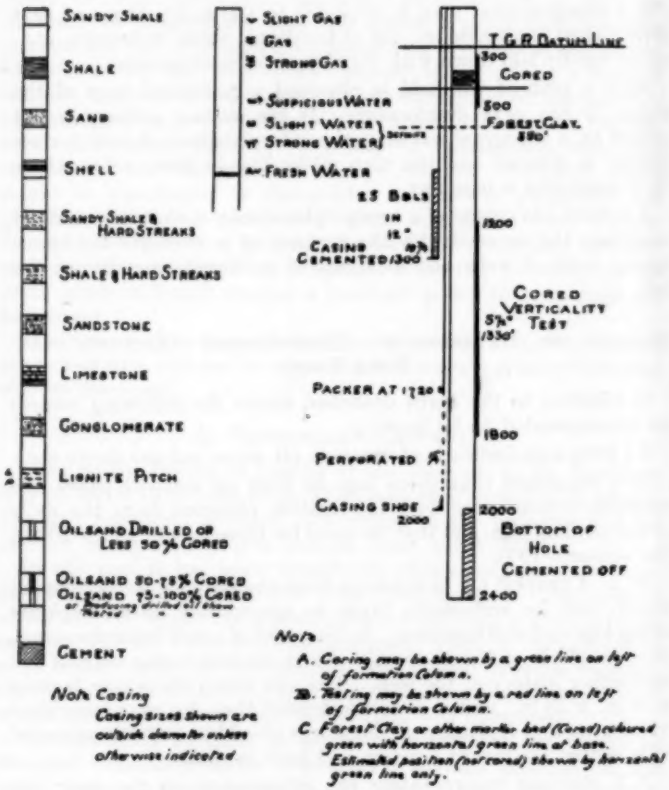


Fig. 1.

Convention for Graphic and Section Logs.

General Records.

It is advocated that these records be standardized so that :—

(*a*) They are of a uniform size.

(*b*) The Government returns be incorporated in the system of proposed records as far as possible.

(*c*) Generally speaking, they should be mostly based on, and in many cases incorporated with, daily returns.

(*d*) These monthly records should be the basis of the corresponding annual returns, and the annual returns should be

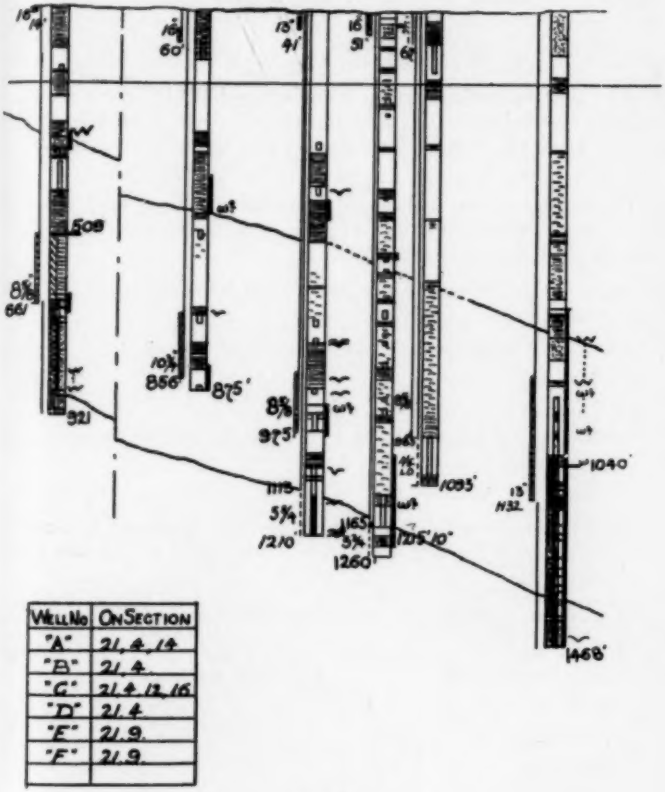


FIG. 2.

devised for filing separately with the previous annual returns, thus forming a complete and consecutive record of that particular phase of operations.

(*e*) As far as possible the minimum number of returns should be made compatible with complete records and no overlapping of information should occur.

As far as possible all technical records and statistics should be compiled by the technical staff on the fields. This procedure would tend to reduce the work to be done at the head office and ensure that such tabulations were relevant and correct. It would also prevent similar information being duplicated.

Drilling Records.

The first operations to be recorded technically on a field are drilling operations. Accurate records of these from the earliest period is of the utmost importance, and the following forms are suggested :—

D. 1. Tour report to be used by drillers for all work done on wells and countersigned daily by the Drilling Superintendent and Petroleum Engineer. (See Fig. 3.)

On it the following information should be recorded :—

(1) Formation passed through.
(2) Coring information. Recoveries and descriptions.
(3) Bits used.
(4) Delays.
(5) Weights of mud and other information relative to mud used, as viscosity, etc.
(6) Tests for verticality.

Such information is invariably desired by local management of the company, especially if the head local office is situated away from the fields.

D. 2. Such compilations of information may be sent weekly.

D. 3. A monthly development report is submitted for exchange with other companies under the following headings :—

Well No.
Location.
Elevation.
Depth.
Casing.
Status.
Description of operations during the month.

A tabulation of the forms under discussion follows. They are referred to under reference number as above, and the Government Forms are also recorded.

Technical Records.

Ref. No.	Description.	Period.	No. of copies.	Distribution.	Remarks.
G. 1	Covering letter for all work done on field.	Monthly.	3	Govt. Head Office (Trinidad) File.	Govt. Form I.
G. 2	Log of work done on drilling wells.	Monthly.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form II.
G. 5	Presence of water-bearing strata.	As required.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form V.
G. 6	Certificate of test for water shut off.	As required.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form VI.
G. 7	Notice of intention to drill.	As required.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form VII.
G. 8	Notice of intention to deepen, re-drill or alter casing, plug, abandon, or use explosive.	As required.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form VIII.
D. 1	Drilling report.	Daily or each tour.	2	Driller File.	
D. 2	Report of work done on wells for Company records.	Less than 1 month.	3	Head Office (Trinidad) File.	
D. 3	Development report.	Monthly.	As required.	Head Office (Trinidad) Other Companies. File.	For exchange with other companies.
D. 4	Casing tally.	As required.	2	Stores Dept. File.	
P. 1	Production return.	Daily.	2	Prod. File.	
P. 2	Production return.	Monthly.	2	Prod. File.	
P. 5	Water and oil gauging.	Monthly.	2	Prod. File	
P. 6	Maintenance report on well.	As required.	1	File.	
G. 3	Production return.	Monthly.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form III.
G. 4	Abstract of oil stored, consumed and refined.	Monthly.	3	Govt. Head Office (Trinidad) File.	Govt. Return Form IV.
P. 7	Graphic production.	Plotted bi-daily for one year.	1	These forms should be kept in books on the fields.	
P. 7a	Monthly oil and water graphs.	Monthly for 40 months.	1	As P. 7.	
P. 7b	Oil and gas lift data.	Monthly.	1	Compiled from meter reading.	
P. 7c	Operation data.	Yearly.	1	Compiled from P. 7.	
P. 8	Individual well production cards.	Monthly.	1	Permanent Record.	
G. A.	Well history record.	As required.	1	Permanent Record.	
G. D.	Drilling costs and statistics.	As required.	2	Head Office (Trinidad) File.	
S. 1	Strip log.	As required.	1	Filed at Field.	
S. 2	Graphic log.	As required.	1 & T.	Permanent record and tracing should be made.	
S. 3	Geological sections.	As required.	4 & T.	3 Head Office (Trinidad) 1 File.	Tracing could be modified from time to time.
S. 4	Typed description of cored formation.	As required.	2	File. Spare.	
D. 5	Derrick alterations.	Monthly.	3	Head Office (Trinidad) File. Spare.	

TOUR DRILLING REPORT.

WELL

.....day Date..... .....193..... From.....a.m. p.m. to.....p.m. a.m.

CASING.

Dia.	Beginning of Tour	Extracted	Inserted	End of Tour

Depth of hole beginning of tour.....

Footage drilled.....

Footage cored.....

Depth of hole end of tour.....

Description of Formation	Depth of Base	Gas Oil and Water Shows

Description of Cores
(Filled up by pet. engineer only)

CORE RECOVERIES.

From..... to..... Recovered.....
From..... to..... Recovered.....
From..... to..... Recovered.....
From..... to..... Recovered.....

BITS.

No. of bits changed.....
Footage per bit.....

VERTICALITY TEST	Depth	Inclination

SIZE OF OPEN HOLE

Drill Pipe for Bottom at End of Tour.

Drill Collar and Bit.....

Core Barrel.....

Stands .....

Singles .....

Kelly .....

DRILLING MUD DATA.

Time	Depth of Well	Weight of Mud Out	Weight of Mud In	Remarks

DRILLER'S REMARKS.—*I have examined the works comprising the Drilling Outfit at the above well and find they are satisfactory, except :—*

.....
Driller.

OTHER REMARKS AND INSTRUCTIONS.

....
Drilling Supt. *Pet. Engineer.*

FIG. 3.

Well File.

All forms relating to a well should be incorporated in a folder. The raised tabs should have coloured strips attached with the well number. The colour of the tabs should indicate the locality of the well.

Well No. .....

CASING RECORD.

...t..... Wt. per ft. ..... Threads..... Amt. .....

...pth of Shoe..... Amt. of Cement..... ..... Brand of Cement..... .....

...te of Cementing Casing.....

...te of Testing Casing..... Dia. of Hole in which Casing is Set.....

Feet	Inches	Total Feet	Inches	No.	Feet	Inches	Total Feet	Inches	No.	Feet	Inches	Total Feet	Inches
				31					61				
				32					62				
				33					63				
				34					64				
				35					65				
				57					67				
				58					68				
				59					69				
				60					90				

.....Joints Perforated from..... to .... Size of Perf. .....

...cker at..... Spacing of Perf. .....

...ight of Slurry..... .....

...HER REMARKS :— Cementing Job Ref. No. .....

....
Drilling Supt.

....
Pet. Engineer.

FIG. 4

CASING RECORD (D. 4).

The forms should be arranged in the folder in chronological order and consist of the following :—

G. 2, G. 5, G. 6, G. 7, G. 8, B. 4 (typed description of cored formation), D. 4 (Casing Tally), any analysis of oil or water, small map showing exact location of well as sent with G. 7.

A casing tally form is submitted and is suggested as a permanent record. The use of such a form will generally tend to make measurements of casing more accurate. (See Fig. 4.)

The essential particulars of the cementing job, as amount of cement used, brand of cement, weight of slurry, etc., should be recorded in a separate book for the purpose. These records should be numbered, and the number entered on the relevant casing tally to afford easy reference.

It is not recommended that any production data be kept in the well files. Graphic production and maintenance logs should be retained in loose leaf books and monthly productions in separate folders.

Government forms have the reference letter G., and the following is a description of those alluded to above :—

G. 2. Log of work done on drilling wells.
G. 5. Presence of water bearing strata.
G. 6. Certificate of test for water shut off.
G. 7. Notice of intention to drill.
G. 8. Notice to deepen, re-drill or alter casing, plug, abandon or use explosive.

In addition to the above forms it is suggested that the introduction of the following tabulations might be desirable.

G. A. Well History Record. (See Fig. 5.)

The value of this form lies in the fact that all information relevant to the drilling of a well is included and the filling in of such a form when the well is completed definitely ensures :—

(*a*) No information has been overlooked or omitted.
(*b*) Such information is readily accessible.

G. B. Drilling Costs and Statistics Record. (See Fig. 6.)

This type of record is proposed to ensure that as particularised costs as possible are available for each and every well.

Relevant statistics are tabulated on the same form. The particularised costs (if accurately kept) should determine the comparative economies of the drilling, especially as these are recorded side by side with the relevant variable statistics as per cent. Coring, Depth of Well, per cent. delays, etc., etc.

The form has been drawn up with the object of endeavouring to ascertain comparative efficiencies of drilling equipment and with a view of trying to locate reasons for increase or decrease in drilling costs. It may be asserted that aggregate costs of drilling for a year give all the data required, but on the other hand it seems possible that only particularised analysis of data can show where economies have been effected and where waste has occurred.

Form G. A. might be attacked on the ground of duplication of data and form G. B. might encroach on the domains of higher accountancy, but in spite of this it seems that these, or similar forms, might be usefully adopted.

Completed.....
Abandoned.....
Well No. .....

Elevation Top of Conductor.	Elevation of Derrick Floor	Elevation Top of Rotary Table	Depth of Well	Co-ordinates
				X= ..... Y= .....

Dates of Progress.	Rigging Up	Drilling	Standing	Fishing
	% Time	% Time	% Time	% Time

Drlg. Derrick Prom.	Description	Erected	Remarks
,,			

	Description	Size of Hole	Verticality		Coring
			Depth	Incl.	Feet Cored..... ,, Recovered..... % ,, ... % Cored.....
Drilling Machinery Used.					Remarks on Abandmt.

Casing :—Conductors and Water Strings	Size	Weight	D. of Shoe	Amt. of Cement	Brand	Remarks

Oil Strings, Liners, Combination Strings.	Size	Weight	D. of Shoe	Perforations	Size	Remarks

Plugs, Bridges, etc.	From	To	Material	Result	Remarks

Side-tracked ing and Junked.	Size	From	To	Remarks

Deepening.	Date	From	To	Remarks

Formation.
Surface ..
Base of F. C.
,, "B"
,, "D"

Formation Tests.	From	To	Method	Result

Repairs, Alteration of Casing, etc.	Date	Description of Operations	Remarks

Water Zones.			Gas Zones.				Oil Zones.				Production
m	To	Analysis	From	To	Pressure	Nature	From	To	Test	Sp. Gr.	

General Remarks :—

FIG. 5.
WELL HISTORY RECORD (G.A.).

DRILLING COSTS AND STATISTICS FOR | Well No. .....

		Date	Days	Remarks
Clearing Site, including Road ..	Commenced	.....	.....	.....
	Completed	.....	.....	.....
Derrick Foundations	Commenced	.....	.....	.....
	Completed	.....	.....	.....
Rigging Up	Commenced	.....	.....	.....
	Completed	.....	.....	.....
Drilling	Commenced	.....	.....	.....
Well	Completed	.....	.....	.....

Costs	£	Cost per Foot
PRELIMINARY.		
1. Road		
2. Clearing site		
3. Earth work		
Total		
DERRICK.		
1. Slush pit {Material / Labour		
2. Foundation {Material / Labour		
3. Derrick {Material / Labour		
4. Rigging up {Material / Labour		
5. Steam and water lines		
6. Shop work		
7. Transport		
8. Lights		
9. Drillers' salaries ..		
10. Superintendence ..		
11. Repairs		
12. Steam plants		
Total		
DRILLING.		
1. Hire of equipment, including depreciation		
2. Drillers' salaries ..		
3. Rig labour		
4. Supplies		
5. Fittings		
6. Shop work and repairs		
7. Power expense ..		
8. Water expense ..		
9. Mud expense (central mud plant)		
10. Electricity		
11. Transport		
12. Superintendence ..		
Total		
13. Casing		
14. Cement		
15. Barytes		
Total costs ..		

Statistics	Ft.	%
Footage drilled		
Footage cored		
Total depth		100

	Days	%
1. Days drilling		
2. Days coring		
3. Days running and setting casing		
4. Days delay—		
A. Fishing		
B. Repairs		
C. Testing		
D. Idle		
E. Other causes ..		
Total drilling time		100

	Size	Cement used	Remarks
Casing ..			
Conductor ..			
Water string			
Oil string ..			

Round trips to change bit.....
No. of days worked on tour.....
Tons of barytes used.....
Description of derrick.....
Description of machinery.....

REMARKS :—

FIG. 6.

DRILLING COSTS AND STATISTICS RECORD (G.B.).

Production Records.—The production of wells is recorded on the following series of forms which incorporate all essential production data.

Production records which appear necessary are as follows :—

P. 1. Daily return of production (for daily total and individual well productions).

P. 2. Monthly Productions of Individual Wells by days. (See Fig. 7.)

P. 5. Monthly Productions of Oil and Water of Individual Wells arranged in batteries by days. Centrifuge tests can also be recorded on this form. (See Fig. 8.)

P. 6. Maintenance report on wells. (See Fig. 9.)

P. 7. Graphic production logs of wells which incorporate the information of P. 6. Semi-log paper is recommended for this form. (See Fig. 10.)

P. 7a. Monthly Percentages of Water and Monthly Oil. Well making water should have the monthly water percentages recorded on ordinary graph paper along with the monthly production of oil. Percentage water recorded should be water to gross fluid.

P. 7b. Gas Lift data and Gas Oil ratios, gas in or out. (See Fig. 11.)

P. 7c. Record of operating days, winch work, etc. (See Fig. 12.)

P. 8. Individual well monthly production cards. These cards should be kept on the fields. Each field should be arranged numerically in a folder. The card will take eight years' production and should be kept up to date every month. Cumulative productions are also recorded. (See Fig. 13.) From this form proportional production tables should be compiled. (See A. 5, Fig. 16.)

G. 3. Monthly Production return for the Government.

G. 4. Abstract of Oil stored, consumed or refined.

The most important production record is the graphic production log (P. 7) (Fig. 10) which records daily productions on semi-log paper. Production of water and gas oil ratios with bean changes are also recorded on these graphs together with the maintenance data. From these graphs the form P. 7c (Fig. 12) submitted is filled in, which incorporates data with regard to restriction and winch work.

Barrels and Tons.—In general it is recommended that all production records be kept in barrels. This advvice cannot be followed with complete advantage unless the ton is eliminated completely. The use of the ton by the Government for the compilation of royalty and calculation of costs per ton are factors which render the universal application of barrels very difficult. It would seem much more logical to exclude the ton entirely from

.....Field.

CRUDE OIL PRODUCTION FOR MONTH OF ..... 19.....

Well No.	Prod. Meth.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Totals	Remarks

FIG. 7.

MONTHLY PRODUCTION OF INDIVIDUAL WELLS BY DAYS. (P. 2.)

.....Field.

GAUGING REPORT BATTERY NO. ..... MONTH OF ..... 19.....

Well No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Totals Gauged	Totals for Month	Per cent. Water	Remarks
	W																																			
	O																																		
	W																																		
	O																																		
	W																																		
	O																																		
	W																																		
	O																																		
	W																																		
	O																																		

FIG. 8.

MONTHLY PRODUCTION OF OIL AND WATER BY INDIVIDUAL WELLS. (P. 5.)

both refinery production and government returns than to use tons throughout all records.

Note on Production Records.—The production records as enumerated above seem sufficient to meet the necessities of the situation. P. 1, P. 2 and P. 5 if correctly returned ensure that gauging is correct and sufficient tests for water and sand are taken. The centrifuge tests which are made can be recorded on P. 5 in coloured ink. Such tests are primarily valuable for sand percentages. The water percentage is of only secondary value and should only be made use of if no gauge tests are available.

The specific gravities of oils from wells should be taken and recorded on G. 3. It is generally considered sufficient if this test is taken once a month. Any commercial method by which these samples can be taken always leaves large sampling errors probable, and as far as is known changes in specific gravity do not normally occur except over long periods. Special arrangements involving extra specific gravity tests can always be made in unusual wells.

NAME OF COMPANY.

Well No. .....

WELL.....

FIELD.....

DEPTH.....

Casing	Junk	Tubing	Rods	Anchor		Nipple	Date
				Gas	Mud		

Type of Pump ..

Date .. ..

Date	Work Done

FIG. 9.

MAINTENANCE REPORT ON WELLS. (P. 6).

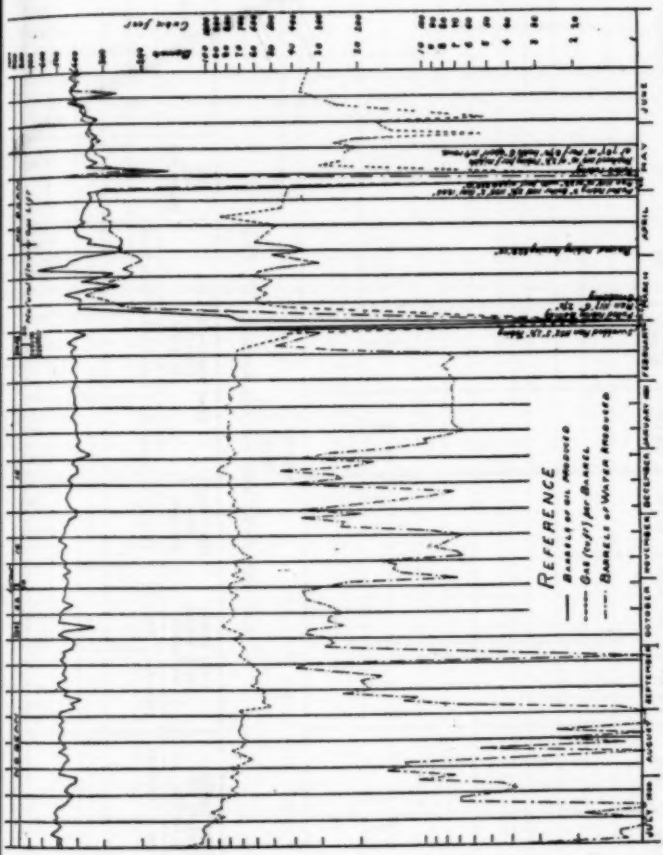


FIG. 10.

GRAPHIC PRODUCTION LOG OF WELL (P. 7.).

NAME OF COMPANY.

Fluid is gauged in barrels.
Gas is gauged in cubic feet.

Date	Production		Gas In per Hour	Gas Out per Hour	Gas In to Oil	Gas Out to Oil	Formation Gas to Oil	Hours Off	Remarks.
	Water	Oil							
1									
2									
3									
4									
5									
6									
28									
29									
30									
31									
Total ..									
Averages.									

Month of ..... 19..... Well No. ....Field

FIG. 11.

GAS LIFT DATA AND GAS-OIL RATIOS. (P. 7B.)

Well	Total Yearly Prod. of Oil in barrels		Total Yearly Prod. Water in barrels		Operating days for year	Time Distribution for 1930-31 in days			Per cent. Restricted	Remarks.
	1929-30	1930-31	1929-30	1930-31	1929-30	Operating	Restricted	Winch Work		

FIG. 12.

RECORD OF OPERATING DAYS. (P. 7C.)

NAME OF COMPANY.

Well.....
Field.....
Location.....
Date of Completion.....

Water

Initial Prod. 24 hrs. .....
How Produced.....
Producing Zones..... .....

Month	Prod.	Cumulative	Remarks	Month	Prod.	Cumulative	Remarks
July ..				July ..			
August ..				August .			
June ..				June ..			
Total ..				Total ..			
July ..				July ..			
August ..				August .			
June ..				June ..			
Total ..				Total ..			
July ..				July ..			
August ..				August .			
June ..				June ..			
Total ..				Total ..			
July ..				July ..			
August ..				August .			
June ..				June ..			
Total ..				Total ..			

FIG. 13.

MONTHLY PRODUCTION CARDS. (P. 8).

FIG. 12. RECORD OF SUBSEQUENT RUNS. (P. 7).

It is recommended that a two-gallon sample from every producing well should be taken once a year. On this sample a specific gravity determination should be made and a distillation test carried out.

Miscellaneous Records and Well Charts.—In addition to the records as described above, description of cores taken should be written up in a core book. On completion of the well two typewritten copies of the formation cored should be filed in the well file. Core recoveries should be recorded in a separate book. (B. 4.)

It is advisable to extend the use of manuscript books for keeping rough drafts of the annual tabulations described below.

Other forms used are :—

G. 1, which is a covering letter to the Government for all drilling and repairing work done on the field for the month, and shows the wells which have been abandoned.

G. 4, which shows the oil stored, consumed and refined.

D. 5, a form showing the alterations, additions to, and movement of derricks, is suggested as a proposed return. This form is more desirable as the use of steel derricks becomes more general. The return also ensures that the number and condition of the derricks at any time are known and automatically keeps the inventory of derricks accurate and up to date. (See Fig. 14.)

ALTERATIONS OF DERRICKS FOR

MONTH .....

YEAR .....

Well	Description of Derrick	Erected, Removed or Demolished	Remarks

FIG. 14.

Wall Charts. (See Fig. 15.)—Experience has shown that certain data are constantly in use and should be readily accessible. Such data should be arranged for ready reference and constant use.

W. 1 *and W.* 2.—These two records can be made on drawing paper and may be arranged for placing in frames under glass. The forms should be spaced for filling in the data with a typewriter. Such records are permanent.

Monthly.—Further records which should be kept up to date daily for a month are suitably applied to Production, Fuel and Footage, viz. : W. 3, W. 4 and W. 5. These should be kept for ready reference on the wall or on a stand, and kept up to date.

WALL CHART (PERMANENT).

W. 1 (for quick reference).

Well No.	Description	Elevation	Depth	Depth Base Marker	Prod. Zone	Date First Prod.	Date Last Prod.
M. 499		161·4	2972	1452	G	28/4/34	29/11/34
M. 500		153·9	3025	*1570*	G	11/7/34	
M. 501		165·7	2843	*1328*	F	15/3/35	
M. 502		160·1		1483			
M. 503		158·7					

= Located. = Drilling. = Producing or theoretically capable of production.
= Abandoned. Italic figure indicates "Cored" or otherwise definite base of marker.

W. 2.

Well No.	20"	15½"	12¼"	11"	10"	8"	6"	5"	4"	Perforated and Remarks
M. 500	6	125	2815					3025		2980–3025
M. 501	8	80		2480				2640		

WALL CHART (MONTHLY).

W. 3. *Monthly Record of Daily Production.*

Date	Field	Field	Field	Total	Total to Date	Previous Month
1						
2						
Etc.						
30						
31						

W. 4. *Monthly Record of Daily Drilling.*

Date	Wells	Total Footage	Footage to Date	Previous Month
1				
2				
Etc.				
30				
31				

W. 5. *Monthly Record of Daily Fuel Consumed.*

Date	Steam Plants	Total Used	Total to Date	Previous Month
1				
2				
Etc.				
30				
31				

FIG. 15.
WALL CHARTS (PERMANENT).

ANNUAL RECORDS.

Return No.	Well No.	Date of Initial Production	Producing Zone	Production from wells first produced during year 1934–35 in tons. July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Total for 1934–35
A. 2	M. 500	11/7/34	G	1032	865	732	453	121	130	110	65	43	22	11	25	3609
	M. 501	15/3/35	F									425	621	412	320	1778
	Totals ..			1032	865	732	453	121	130	110	65	468	643	423	345	5387
	Cumulative				1897	2629	3082	3203	3333	3443	3508	3976	4619	5042	5387	

Productive footage 5668. Return per ft. drilled for productive footage 0·95 tons.
Total footage .. 5668. Return per ft. drilled for total footage .. 0·95 tons.

	Well No.	Depth	Footage Drilled 1934–35	Casing inserted during 1934–35. 20″	15½″	12½″	11″	10″	8″	6″	5″	Casing extracted during 1934–35. 20″	15½″	12½″	11″	10″	8″	6″	5″
A. 3	M. 499	2972	—																2516
	M. 500	3025	476								3025								
	M. 501	2643	2643	8	80		2480				2640								
	Total		3119	8	80		2480				5665								2516

N.B.—Figures give actual amounts of casing used.

	Well No.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	% 1934–35	Barrels Water	% 1933–34	Barrels Water
A. 4	M. 498	2·9	0	7·0	7·1	—	—	7·5	4·1	10·6	7·3	—	—	5·7	257	6·3	472
	M. 499	0	87·5	91·2	93·5	86·7			Being Repaired					89·6	29,784	Neg.	5

	Well No.	Initial	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	7th Year	8th Year	9th Year	10th Year	11th Year	12th Year	13th Year	14th Year	15th Year	16th Year
A. 5	B. 498	25,253	1000	1543	1658	1764	1821	1852	1881	1902								
	B. 497	7,642	1000	1763	2056	2437	2963	3421										
	Average	16,447	1000	1653	1857	2100	2392	2637										

Return No.	Well No.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Total Footage	Depth of Well
A. 7	M. 500	476	—	—	—	—	—	—	—	—	—	—	—	476	3025
	M. 501	—	25	652	973	251	415	164	97	66	—	—	—	2643	2643
	Totals ..	476	25	652	973	251	415	164	97	66	—	—	—	3119	
	Cumulative	476	501	1153	2126	2377	2792	2956	3053	3119	3119	3119	3119		

	Well No.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Total Cored	Total Recovered	Per Cent. Recovery
A. 8	M. 500	476	—	—	—	—	—	—	—	—	—	—	—	476	398	84
	M. 501	—	—	—	673	248	415	160	97	66	—	—	—	1659	1344	81
	Total ..	476	—	—	673	248	415	160	97	66	—	—	—	2135	1742	82

ANNUAL RETURNS (*continued*).

Return No.	Month	Various Fields	Total for All Fields

Return No.	Well No.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Cored	Recovered	Recovery
A. 8	M. 500	476	—	—	—	—	—	—	—	—	—	—	—	476	398	84
	M. 501	—	—	—	673	248	415	160	97	66	—	—	—	1659	1344	81
	Total ..	476	—	—	673	248	415	160	97	66	—	—	—	2135	1742	82

ANNUAL RETURNS (*continued*).

Return No.	Month	Various Fields					Total for All Fields
A. 9	July	7,132	36,413	31·56	1,561	3,125	48,262·56
	August ..						
	Etc.						
	June						
	Total ..	81,517	395,817	213·46	15,437	31,193	524,177·46

(Production in tons.)

		July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Total
A. 10	Total oil													
	Oil produced water-free													
	Watered oil													
	Water made by watered wells													
	Gross fluid by watered wells													
	Per cent. water/gross fluid													
	Per cent. water/total oil													
	Occasional water													

(Productions of oil and water are in barrels.)

	Production Method	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	Totals
A. 11	FLOWING— Per cent. of total													
	PUMPING— Per cent. of total													
	AIR AND GAS LIFT— Per cent. of total													
	GATHERED OIL— Per cent. of total													
	LOSSES— Per cent. of total													

FIG. 16.

Annual Tabulations and Returns. (See Fig. 16.)—Daily returns are of little value except to those very intimately connected with the operations. Monthly returns and annual returns which are compiled from the daily returns are the standards of reference and sources of information for any general statistics.

Monthly returns show the progress of the company's activities through the year and are of use to officials in estimating progress made.

Annual returns are the standards of general development and as such are of primary importance in any investigation into the company's general progress or policy as they embody permanent records of past achievements, and form the basis of estimation of future performances.

The following annual tabulations are suggested :—

A. 2.—Producing wells for current financial year.
A. 3.—Casing inserted and recovered for current financial year.
A. 4.—Water percentages, monthly for individual wells.
A. 5.—Comparative proportional productions.
A. 6.—Abandonment of wells.
A. 7.—Monthly drilling for individual wells.
A. 8.—Monthly coring for individual wells, showing per cent. recovery.
A. 9.—Monthly productions of oil from various fields showing monthly totals for all fields and annual total for separate fields.
A. 10.—Monthly totals of oil and water produced in barrels.
A. 11.—Allocation of production in monthly total and percentages under various producing methods.
A. 12.—Individual well productions.
A. 13.—State of wells at end of financial year.
A. 14.—Fuel consumed shown monthly in barrels or tons of oil and M./cu. ft. of gas tabulated with feet drilled and oil produced.
A. 15.—Footage drilled productive and unpayable, production, etc.

These tabulations should be compiled from the previously described records. In addition to these the following drawings should be prepared :—

A. 1. Field Group Productions. All the wells drilled in a financial year should be considered as one group irrespective to the sands they may be drilled to. Unproductive and productive footages should be noted together with the number of the wells drilled. The annual and cumulative productions of each group should be recorded together with the total production of the field for the year and the cumulative production to date. From this table

A. 6.

Well No.	Date of Abandonment	Reasons for Abandonment	Remarks
M. 499	30/6/35	Water	An attempt to repair this well proved a failure. 5" oilstring was recovered and the well abandoned.

A. 12.

Well No.	Depth	Date Commenced Producing	Date last Produced	Prod. for 1934–35	Prod. to 30.6.35
M. 499	2972	28/4/34	29/11/34	1342	5481
M. 500	3025	11/7/34		3609	3609
M. 501	2643	15/8/35		1778	1778
				6729	10,868

A. 13.

Producing June 30th, 1935	Idle	Idle due to restriction	Abandoned	Recommended for Abandonment
M. 500 M. 501	M. 480		M. 499	

A. 14.

Month	Fuel Oil (Tons)	Crude Oil (Tons)	Gas used as fuel (M/Cu. ft.)	Footage Drilled	Production
July.. ..					
August ..					
June ..					

estimates of future productions for the wells can be made. (Figs. 17 and 18.)

A. 15. This table should be compiled to show the following :—

Total footage drilled, Productive footage, Unpayable footage, Production of existing wells to date, Ultimate production of 1000 tons, Total wells, etc., etc. (See Fig. 19.)

Footage per well, tons per foot ultimate, tons per foot drilled to date, reserves of present wells, and per cent. unpayable/total footage are plotted graphically (from data in A. 15). (See Fig. 20.)

A production map should be submitted showing the production and state of wells to date. A scheme of reference is attached. Two graphs are incorporated with this map. The yearly productions of the various groups should be shown on one graph and the yearly productions from the various sands on the other. (See Fig. 21.)

It is suggested that all the annual tabulations be submitted on loose leaves suitably punched for filing with previous annual tables.

Groups and Years	Well Numbers	Unproductive Wells and Footages	Productive Footages	23–24	24–25	25–26	26–27	27–28	28–29	29–30	30–31
I. Prev. 23–24	0, 1, 2, 3, 4, 5, 5A, 6, and 8.	0, 5 818	8,242	41,195	6,714 47,909	3,422 51,331	3,639 54,970	2,135 57,105	1,902 59,007	1,189·6 60,196·6	731 60,927·6
II. 23–24	0, 7, 9, 10, 11, 12, 13 and 14.		10,994	38,318	5,894 44,212	5,072 49,284	3,450 52,734	2,801 55,535	3,139 58,674	2,867·9 61,541·9	2,186 63,727·9
III. 24–25	0, 15, 16, 17, 18, 19, 21, 22 and 24	0, 15, 16, 21, 24 5935	5,839		4,612	11,288 15,900	6,336 22,236	4,024 26,260	5,102 31,362	4,307·6 35,669·6	3,758 39,427·6
IV. 25–26	0, 20, 25, 26, 27, 28, 29, 30, 31 and 33.	0, 30 2308	14,278			7,464	3,442 10,906	2,511 13,417	2,111 15,528	1,900·7 17,428·7	1,328 18,756·7
V. 26–27	0, 34, 35, 36 and 37	0, 35 and 37 4045	4,401				1,010	729 1,739	568 2,307	523·8 2,830·8	412 3,242·8
VI. 27–28	—		—					—	— —	— —	— —
VII. 28–29	0, 23, 40, 41, 42, 43, 44 and 45.	0, 23 2181	3,768						6,845	3,219·3 10,064·3	1,679 11,743·3
VIII. 29–30 30–31	0, 47, 48, 49, 50, 51 0, 52 and 55.	—	5,992							1,687·9	906 2,683·9
					17,220	27,246	17,877	12,200	19,667	15,967	11,090
		15,287	53,511	79,513	96,733	123,979	131,856	154,056	173,723	189,420	200,510

From graph. (Fig. 18). Total cumulative to end of 38/39.

Group	Cumulative
I. ..	64,000
II. ..	72,000
III. ..	52,500
IV. ..	25,000
V. ..	4,000
VI. ..	—
VII. ..	19,000
VIII. ..	5,000
Total ..	241,500

Total estimated cumulative production of 241,500 tons to end of 38/39, from graph (Fig. 18), less total production to 30/31 (200,500 tons) gives a figure for reserves (on eight-year basis) of 41,000 tons.

FIG. 17.

GROUP PRODUCTIONS.

Equipment Records.—Apart from the technical records which have been described above, and which relate exclusively to chartography, drilling and production, a third class of records seems desirable not merely to know what equipment is available (outside the stores) but where the equipment is situated. Further, it seems indispensable to keep records from which the performances of various equipments can be computed.

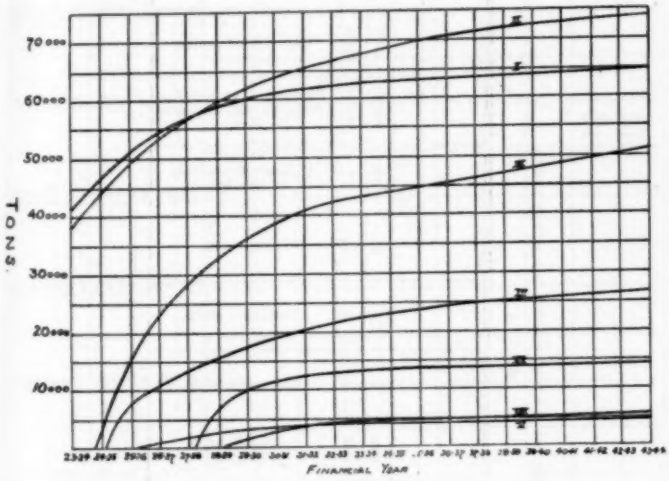


FIG. 18.

CUMULATIVE GROUP PRODUCTION CURVES FOR ESTIMATION OF OIL RESERVES AND ULTIMATE PRODUCTION.

With this end in view it is necessary to have a card index system of all the plant on the field, and similar units should be distinguished from each other by numbers and have a separate card on which is recorded the repairs and movements of the unit. Such a system properly card indexed and rigidly applied would ensure an accurate inventory being available at any time and that the performances of equipment could be computed.

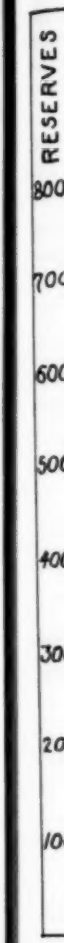
The economy and suitability of equipment could be thus ascertained and the length of the future economic life of such plant determined. Such information would be particularly valuable with regard to draw-works, winches, rotary tables, drilling engines, slush pumps, etc.

FIELD.

Group.	Total Footage.	Productive Footage.	Unpayable Footage.	Production of existing Wells at end of each Year.	Ultimate Production in 1000 tons.	Total Wells.	Productive Wells.	Unpayable Wells.	% Unpayable ft. Total ft.	Total ft. No. of Wells.	Tons per Well to date.	Tons per ft. to date.	Tons per Well, Ultimate, in 1000 tons.	Tons per ft. Ultimate.	Reserves of existing Wells at end of each year, in 1000 tons.
I.	9,909	6,630	2,749	17,323	55	7	5	2	29·3	1,328	2,474	1·85	8·0	5·9	38
II.	17,552	11,728	5,826	36,008	100	13	7	4	33·2	1,350	2,770	2·05	7·7	5·7	64
III.															
&c.															

FIG. 19.

TABULATION OF UNDERGROUND DEVELOPMENT.



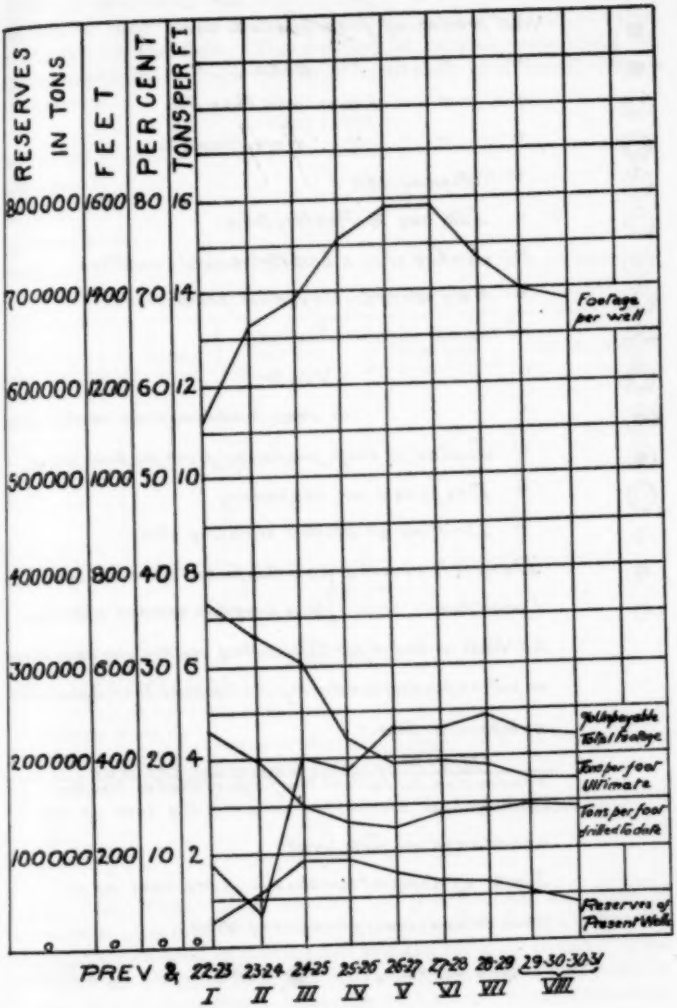

RESERVES IN TONS
FEET
PER CENT
TONS PER FT
800000 1600 80 16
700000 1400 70 14
600000 1200 60 12
500000 1000 50 10
400000 800 40 8
300000 600 30 6
200000 400 20 4
100000 200 10 2
0 0 0 0
Footage per well
Tonnage Total Footage
Tons per foot Ultimate
Tons per foot drilled to date
Reserves of Present Wells
PREV & 22-23 23-24 24-25 25-26 26-27 27-28 28-29 29-30-30Y
I II III IV V VI VII VIII

FIG. 20.

UNDERGROUND DEVELOPMENT.

Well producing from shallow sand

" " " deep "

" " water less than 5%

" " " more than 5%

" standing idle.

" Idle due to Restriction

" Junked or in a bad Mechanical Condition.

" Abandoned - No further production.

" " - Junked.

" " - Water

" " to deep, producing from shallow sand.

" Junked to deep, producing from shallow sand.

" Deepened or deepening

" Drilling or drilled to casing shoe

Derrick erected } Location for next Financial Year.
Location } Have Location numbers in Green.

All Wells drilled or partially drilled, worked over, abandoned or put on production during the Financial Year have well numbers in Red.

Total Production to end of Current Year
Production for Current Year / Age of Well in Months

Date of Last production shown in the case of an abandoned or Idle Well.

Date of Completion shown in the case of an abandoned non-producing Well.

● = Green ● = Red ◎ = Blue.

FIG. 21.

STANDARD REFERENCE FOR USE ON PRODUCTION PLANS.

After a card index was made it might be beneficial to make an equipment map which would show the location of all movable machinery on the field. The position of various units could be distinguished by movable pieces of cardboard of different shapes and colours.

WIRE LINES.

Maker's Name .....

Maker's No. ..... Stores No. .....

Description .....

Construction and Lay .....

Tensile .....tons per square inch.

Date issued ..... Date scrapped .....

Well No.	Footage	Total Footage Since Issue	Total W. Days Since Issue	No. Ton Miles

REMARKS :—

Tons Mile Formula (Anderson).

Drill Pipe.—Ton miles per round trip $+ (n = n^2)\ (0{\cdot}000766\ w) + 0{\cdot}170\ n$

or

$$\frac{L\ 20{,}000 + w\ L}{10{,}560{,}000}$$

where n = number of 90′ stands of D.P.
L = length of string of D.P. in feet.
w = weight per foot of D.P. in lbs.

For Setting Casing :—

$$\text{Ton miles per string} = \frac{L\ 20{,}000 + w\ L}{21{,}120{,}000}$$

where L = length of casing string in feet.
w = weight of casing per foot (in lbs.).

.....
Drilling Superintendent.

FIG. 22.

Performance of Wire Ropes.

Pipe Line Maps.—Maps showing the position, size and duty of the various pipe lines are extremely useful and well repay the care which is necessitated in making and keeping them up to date. Pipe line maps are the only means of indicating the extent and position of this class of equipment, and show at a glance where economies can be effected and are the only reliable basis for the preparation of new programmes of distribution and collection of oil, water, gas, etc.

Performances of wire ropes seem very desirable information to obtain and a form is submitted which has been devised by L. A. Bushe, Esq., Drilling Supt., at the Apex (T'dad) Oilfields, Ltd., for obtaining these data. (See Fig. 22.)

Such a series of equipment records tend to centralise the control of all machinery by one department. It is felt, however, that in practice operation of machinery used in the drilling and production departments should be under the control of that department. Maintenance and supply of this machinery should be the responsibility of the Engineering Department.

This situation calls for very intimate co-operation between the drilling, production and engineering departments, and there seems to be no reason under present conditions why this desirable condition should not be attained.

Fishing Tools.—A special note with regard to this class of equipment seems relevant as it is a highly controversial subject and the suggestions which follow are made with a view to promoting discussion.

A card index on the lines suggested above is advocated. Each tool of the same class and dimensions will be differentiated by a number. All left-hand tools should be painted red or some other distinctive colour. The various tools should be arranged in sizes rather than in classes, *i.e.*, all fishing tools for 5 in. should be together rather than having all overshots, spears, etc., various sizes, in one place.

It would seem advisable to keep all fishing tools in a central store and to a great extent on one particular field. In the past it has been found that fishing tools have remained on wells and have not been returned long after they are finished with. Moreover, a selection of tools is often withdrawn from the stores, and the whole selection is frequently kept on the well doing nothing.

To obviate such occurrences it is suggested that a fishing tools capital account be opened. Every tool would have a figure for daily hire. A suggested figure is 1/30 of 10 per cent. of capital value per day or portion of a day. The user of the tool would pay for any repairs or for the capital value of the tool if lost in addition to the daily hire. The hire would be subtracted from the capital value and this amount would be available for purchase of further fishing tools. The value of tool which was lost would be cost on field less amount credited for hire of tool. Thus a tool with a value of $3000 would have a daily rental of $10+repairs if necessary+transport if not supplied. A minimum rental of $1.00 might be suggested and a larger daily amount might be charged for hire as 1/30 of 33⅓ per cent. or 20 per cent. of capital cost.

Conclusion.—The organisation of a field necessarily determines the number and kind of records which can be used advantageously. If a particular series of records is considered to be theoretically perfect and it is found on applying them to a field that they are not suitable, it probably indicates that the organisation is not theoretically sound.

The capabilities and characteristics of various heads of departments on a field might frequently determine in some degree the method of keeping and the character of the records which are kept.

It cannot be too strongly urged that all records should embody both reliable and useful data. If any return is manifestly inaccurate, or not useful, it should be promptly discarded as the compilation of such documents tends to bring the whole system into disrepute and disregard.

Consideration of the whole subject of records must convince one of its fundamental importance. Even the comparatively circumscribed paper submitted must indicate its close relationship with broad lines of policy and system of accountancy.

Further it is very probable that future economies which will produce better and more stable conditions in the oil business depend to no small extent on the accuracy and character of the data which are now being recorded.

DISCUSSION.

Mr. H. D. Fletcher said the Author had covered most of the ground there was to cover. In his opinion records were of the utmost importance, particularly in regard to old wells that had been producing for a long time. In the old days lack of records used to be, to a very great extent, the cause of much unnecessary work and expenditure because one could not tell what the condition of a well was when undertaking deepening or repair work. It generally happened that on going back to a well one found some obstruction of which there was no record and which led to long fishing jobs. The accuracy of records was of first importance, and particularly so in the cost of work, as all new, increased or reduced operations depended entirely on past records to decide whether the expenditure was warranted.

He thought that before any system of records was adopted by a Company it should be fully discussed by the management with all the heads of departments concerned and after its adoption no change should be permitted without the consent of the management, otherwise members of a staff were liable to start voluminous records of their own which often only they understand and very often were of little or no use to the Company. He had seen cases, especially where one had a migratory staff, of a man who spent two

or three years with a Company starting one system of records of his own and after he left another came in and started another system, with the result that one got more records than were necessary, some being repetition and some useless, so that the system should be very thoroughly discussed before being adopted and no change should be permitted until it had first been thoroughly gone into and passed. Unless something of the kind was done there was always a risk of repetition and an accumulation of useless records.

Mr. W. J. C. Cooke asked the Author if records relating to the use of heavy muds and their loss in drilling wells had been kept, as he thought it would be interesting.

Col. H. C. B. Hickling said with regard to the question of mapping and topography, the Author declared that: "The irregular occurrence of the oil sands makes the problem of spacing of necessity always intimately connected with topography." Further on he said: "Theoretical spacing of wells must, in the nature of things, be subservient to topography when both the oil sands and surface are irregular."

He thought that spacing in Trinidad was generally theoretical, and although the irregular occurrence of sands be accepted yet such would not be known with such certainty as to affect theoretical spacing. Topography must and will cause diversion from theoretical spacing but topo-mapping would be, in his opinion, uneconomical, if done with such accuracy that the location of wells and roads could be settled from maps. Final location of wells and roads must, in his opinion, always be on the ground. He did not think locations should be altered to any great extent on account of the difficulty of locating roads, one must use commonsense and generally balance up everything; but he did not think one could move wells to the extent the wording of the paper would suggest.

In the same context: "Theoretical spacing of wells must in the nature of things be subservient to topography when both oilsands and surface are irregular"; that was purely a question of degree, he thought. Later on the Author said: "If the topographical mapping is available in the early stages of field development the whole lay out of buildings, roads, reservoirs, etc., can be rigidly laid down with very appreciable economies." He hardly agreed with the word "rigidly." He was doubtful whether rigidity was practicable at that stage. He thought a field developed as it went along and that one could not in the early stages lay down anything at all with rigidity.

With regard to the paragraph "A further advantage of a topographical map is that it materially minimises the necessity for the services of a surveyor" he thought that it minimised the services

of a surveyor in the later stages only because he had done the work in the early stage.

The recording of "Monthly Productions of oil and water of individual wells arranged in batteries by days" was suggested. He supposed a battery return was better than nothing at all, but he thought that if a well was worth operating it was worth an individual record.

The Author said that "Daily Returns are of little value except to those intimately connected with operations." He thought the wording unfortunate, because the head of the Production Department who was responsible for the maintenance of the production from finished wells was most interested in Daily Returns.

With reference to "Field Group Productions"—he would like to ask the Author to explain further the terms "Field Group Productions."

He was rather puzzled as to the value of Well Records kept in groups according to the age of wells rather than by groups according to the length of productive age. With that alone recorded a great deal of valuable information would be missed. Apparently the Author considered it important also because he mentioned yearly production record from the various sands by graphs. The type production from the various sands was so different that if records were kept in groups of age alone a great deal would be missed.

In the conclusion, the Author stated: "If a particular series of records is considered to be theoretically perfect and it is found on applying them to a field that they are not suitable it probably indicates that the organisation is not theoretically sound." Did the Author rule out the possibility of such a system being theoretically perfect but practically quite unuseable or unsuited for the field?

Mr. L. A. Toone said he thought that Mr. Cooke's suggestion of keeping a record of mud mixed and issued to various wells, weights, etc., would be a valuable addition.

Regarding From D. 5 showing movements, etc., of derricks, it seemed to him that this information would come in more naturally in the Equipment Card Index.

Mr. C. E. Capito said he was in entire agreement with Mr. Harris in advocating the need of proper records on an oilfield and whilst most of those shown were excellent, he thought some of the suggested records could either be simplified or combined with others to reduce the actual number.

There did not seem to be any necessity for keeping both B.1 and B. 2; if the information from the tour reports was to be put direct on to B. 2, there should be no necessity for the strip log, more especially if B. 3 was kept up at the same time. Further,

if monthly productions were also shown on the graphic log there should be no necessity for P. 8.

For better comparison between wells, Mr. Scott's system of recording well productions in 30-day periods as well as in calendar months was excellent, more especially at the beginning of a well's production.

In D. 1 (Tour Report) it seemed to him that there was no necessity to keep horizontal lines in the same plane on both sides of the vertical line. Only one line should be required for the casing and the size of the open hole might be put alongside the casing, cramping up the top part to suit. He thought more room might be allowed for "other remarks and instructions." He also noted there was no place for the driller to mention the number of hours drilling, standing or fishing, as required in the Well History G.A., and the reasons for fishing or standing.

With regard to the issue of a Map with Form G .7, he was hoping that the use of co-ordinates would become more general as it is very simple to pick up a well location when these were given, more especially if the Government grid system was used.

The Well History G.A. seemed to have too much printing on it and as this was a form which was filled up by the Petroleum Engineer he considered the minimum of printed tables should be used on it. A typed list of the information required could be kept and this information entered up by the Petroleum Engineer in the correct order in a large blank space on this form.

Where graphic logs with histories and productions were kept a card type would, in his opinion, be redundant, but should Mr. Harris wish to keep his G.A. he would suggest he had Form G.B. or costs of well printed on the back and thus save space and duplication of searching.

In his office he retained the strip log for use on peg models but the main engineering, geological and production data were kept on a well record card on which the printing had been kept to a minimum.

There seemed to be little reason for keeping both P. 2 and P. 5 unless one was kept for clean oil wells and the other for water/oil wells. Both types of wells should not be on both returns.

Wall charts W. 1 and W. 2 might be combined and made into one sheet; similarly A. 7 and A. 8 might be combined by having two horizontal lines, one for drilling and one for coring for each well.

He used a similar record to A. 11, but with the months vertical, and he combined this information with the number of wells started, completed, abandoned, total footage and production for the Island each month.

With regard to fishing tools, he agreed with the keeping of all classes of fishing tools of one size in one place and in keeping them in a central store with the exception of certain tools constantly required on wells such as the overshot on rotary tool wells and the slip socket and rope spear on cable tool wells, which should be kept at each well to suit the tools used and the size of the hole drilling. As soon as this was changed the fishing tool should be returned to the central store and another set for the next size of tools and hole taken to the well.

He thought Mr. Harris' suggestion of 1/30th of 10 per cent. of the capital cost of the fishing tool as a daily hire rather on the small side. He would feel more inclined to place the hire charge as not less than 2 per cent. nor more than 5 per cent. for each day run. Those fishing tools standing on a well were only to be charged for as run. All repairs and the balance of capital cost to be charged to the well using or losing the tool respectively.

Mr. G. H. Scott said that he considered that while uniformity of records was an ideal it was an Utopian one. Changing conditions and varying methods rendered it almost impossible to devise a general scheme which would meet with universal approval.

Thus if the conventional signs for graphic, and section logs were changed it would entail a tremendous amount of work in order to bring the old wells into conformity with the new system. He might here mention that he could see no point in carrying strip logs as well as large size graphic logs. The large size graphic log should carry all relevant data and should be the one reference for status of well, core recoveries, salinities, divisions of stratigraphy and all general details of the well's history. Naturally for more detailed descriptions the driller's log should be referred to.

With regard to sections, these should also be kept up to date, and in order to make this a simple operation the log could be idealised if such a term can be used. The log on any section should not be so complicated as to fog the main depositional changes on which correlation must be based, and he preferred a coloured log.

Actually, in Trinidad in the oilfield areas, there are very few distinct petrologic changes, and for the purposes of a section these could be divided into :—

Clays
Sands { Oil / Water
Sandy clays
Rock.

The marker bed could be differentiated by a special colour if so desired, but he did not consider this essential. The sandy

clays or sandy shales beloved of the driller could be left uncoloured. Oilsands could be coloured red, as they were the most important feature of the log, watersands blue, and calys purple. By suitable colouring or part colouring any gradations between the main petrologic groups could be mimicked.

He found it preferable for the petroleum engineer to do his own sections, and he would guarantee that a system of colouring was far quicker than a black and white log. He did not think Mr. Harris mentioned a plan showing all section lines. This was of course essential. He considered that all section lines should be true dip ones, even if this involved a very devious and crooked route conforming to changes in regional strike. The beauty of such a system was that firstly there was parallelism of the various beds which was not the case in any section which was not a true dip one, and secondly, if the sections were numerous enough, they served as a basis for all future drilling without the necessity of drawing up new sections.

Passing to some of the specific records :—

D. 1 *Tour Report.*—No space is allowed for viscosity readings of the drilling mud.

Bits and Footage.—It was impossible to gain an idea of bit footages if they were taken together and averaged. There was always the possibility of a bit still being on bottom at the end of a tour and one bit might have drilled only one foot of rock, so that average footages were liable to be extremely misleading.

If the bit footages were required accurately, all bits must be numbered and the driller must only enter his actual footage drilled with any bit. The petroleum engineer could then determine the limits of drilling depth for any one bit. He kept a bit record showing the number of bit, heat treatment and hard facing used, actual footage drilled with the type of formation and the condition of each bit when pulled. This might be considered unnecessary, but it undoubtedly aided in the selection of hard facing and hard inserts and the heat treatment which was most suitable.

Well File.—He did not agree with the mass of material filed on the well file, but agreed that all Government forms and all correspondence be filed on a well file, but considered that oil and water analyses and detailed core reports, casing tallies and such matter were far better filed separately. Oil and water analyses especially were almost always studied with respect to neighbouring wells and a loose leaf book was to his mind far preferable.

Drilling Costs and Statistics Record.—The main difficulty of this form would certainly be in the costing. Unless this was very accurately done it would be impossible to use it for purposes of comparison.

Production Records.—There appeared to be no reason why forms P. 2 and P. 5—monthly production of individual wells—should not be amalgamated. The monthly production of individual wells by days must show all wells so that in order to avoid duplication it would be preferable to show water figures on this one form. These could be entered in red in order to differentiate them from the figures for oil production.

P. 6 *Maintenance Report.*—This form is not suitable for all conditions of a producing well. He had found the most satisfactory system was for the petroleum engineer to hand over a card to the production department showing the exact condition when the drilling department handed over. On the reverse of this card there were special spaces for production notes. These included :—

Flow pipe depths with dates of alteration ;
Chokes ;
Inventory of pumping equipment ;
Date put to pump. Type of pump ;
Changes of pump tubing ;
Fluid levels with dates ;
Any obstructions, etc.

This sheet served as a guide for the condition of a well. From it an inventory of the status and equipment of all producing wells could be simply prepared. This form did not show all pulling jobs if tubing depths had not been changed ; these were shown on the production chart.

With this system Form P. 6 could be dispensed with entirely.

P. 8.—He found it advisable to keep monthly production charts. In their case they did not confine themselves to calendar months, but to months of 30 producing days. In this way decline curves unaffected by months of varying length were obtained. Very often declines which appeared normal on a daily chart showed abnormalities on a monthly one.

These, as the daily charts, were best entered on semi-logarithmic paper, and for purposes of ultimate recovery, rate cumulative curves were very useful.

Mr. Harris states that in his opinion specific gravity records need only be taken monthly. While changes are usually gradual, there are many instances of very rapid fluctuations, and one was often able to diagnose that a series of perforations has been plugged off by a study of the specific gravity determinations. He could not agreee that a commercial method of sampling could be devised to ensure accuracy.

The author also stated that centrifuge figures should be disregarded if gauge tests are available. The amount of water in

suspension in a heavy oil after normal bleeding was very considerable, and if calculated served as a check on the main tank farm bleeds.

Many heavy oils carry 10 per cent. of water in suspension, which would only settle out after lengthy standing.

Mr. C. C. Wilson said he was in agreement with Mr. Scott in stressing the value of graphic logs of wells. Graphic representations of all work on a well and of the results obtained at a well possessed a far greater value for purposes of comparison with those of other wells than did written or tabulated records.

He suggested the addition of a well history graph in which depth was plotted against time in tours. By making depth occupy the vertical direction of the paper and by drawing on the same scale (say 1 inch to 100 ft.) as the graphic log (which also carried casing seats) one could easily see at a glance how drilling time was affected by formation, gas pressure, setting casing, etc., and any unusual delays became apparent.

He suggested that this curve be clipped to the graphic log, so that depths corresponded both sides. To supplement these records, graphic daily production was the only means of comparing the behaviour of two wells producing from similar horizons.

Mr. Harris had suggested that core recoveries should be kept in a separate book from core records. Mr. Wilson considered that core recoveries should invariably be booked in the core record so that the relative value of say two cores of 20ft. length with 100 per cent. recovery in one core and 10 per cent. in the other might be easily distinguishable.

Mr. L. A. Bushe said that Mr. Scott had already dealt with the question of bit records, but he thought that continuous individual bit records, while useful to a certain extent, were apt to be misleading.

He found, on looking up records of bit service for the past two years, that very little reliable information on bit performance was obtainable. This was chiefly due to the fact that it was impossible to know the exact thickness of hard-facing metal used on each bit, the manner in which the drilling was done and the precise nature of the formation drilled. Thus, he frequently found that two bits, reported as being dressed alike and in a similar condition after use, had made the same footage, although in one case the formation was described as "shale" and in the other "sand." Similarly, one bit drilled 20 ft. and another 60 ft., although conditions, including the formation drilled, were reported as being the same.

In spite of these discrepancies he still thought bits should be

numbered and the bit numbers and footage per bit entered on the driller's tour report. If this was done the drilling superintendent could always trace a special bit upon which he might have been experimenting with hard-facing metals or dressing and tempering methods.

Casing Lines.—Mr. Harris referred to wire rope service and he was apparently in agreement with keeping ton mile records on casing lines. He had not, however, provided on his tour report form for the number of round trips made during the tour.

Casing Tally.—It seemed a little unnecessary to include on this form particulars of the cementing job, as this information already appeared on at least two other forms suggested by the author. The chief object of the casing tally sheet was to provide a record showing details of the casing, such as weight, lengths of the joints in the order in which they were inserted, and particulars of perforations, packers, etc.

Fishing Tools.—He could not agree that it was necessary, or or even desirable, to charge out a fishing tool to a well simply because the tool was sent to that well. Nor did he think that any useful purpose would be served by keeping a record of the number of hours or days each tool was used. He viewed it in the light that the tools were paid for by the company and whether they were used on one well or another was not a matter of great importance.

The question of storing fishing tools according to their size or type, he considered, was purely a matter for the discretion of the drilling superintendent, and no hard-and-fast rule should be laid down.

Mr. R. N. Kirby said that for absolute comparative uniformity of production records he thought that production "days" would have to synchronize. For example, the daily completion gauges would all have to be closed at an agreed hour and in the same way the month's figures should be completed at an agreed time and day.

In the absence of a topographical map, contour models in clay of the immediate development area and roughly to scale were of the greatest assistance in determining the lay-out of bridges, roads and well sites over difficult terrain.

Upon the field plan he suggested that it was useful to have the different blocks forming a lease coloured to differentiate between the various titles or conditions under which they are held or worked, which, amongst other things, was likely to affect, for example, the lay-out of a pipe line over a "difficult" land-owner's plot.

General records should only be incorporated with daily records, providing that completion of the latter was not retarded thereby.

It was the practice upon some fields for the drilling tour reports to incorporate the rig crew's time, and Mr. Kirby asked the author if he considered this good practice. If so, the remarks made in connection with the necessity of avoiding delay in the completion of other daily records applied equally here.

He asked the author's opinion upon the loose leaf book method of recording the mechanical history and condition of a well in the form of sheets which could be added to as occasion demanded. Whilst this would not eliminate the Government forms and correspondence, it should form a concise and handy record for use by the field manager, drilling and production superintendents.

Neither in the paragraph headed " Drilling History " nor that headed " Well File " had reference been made to a well log as such, by which is meant a daily journal of all work done upon the well from the time the rig crew rigged-up for drilling, deepening, cleaning or abandoning to the date on which it was handed to the production department or abandoned. Without this verbatim record, it seemed possible that information valuable for the well's history might be lost, for it was often from the expression used in an actual tour report that useful sidelights upon the progress of a well could be recorded.

In the annual returns reference is made to " reserves of present wells," and he thought that this might appear more suitably under the heading of an estimate as it was essentially a potential figure.

Mr. Kirby concluded by saying that the reference at the end of the paper as to the capabilities and characteristics of various heads of departments affecting the efficiency of record keeping would not be overstated by saying that it was essentially the characteristics of heads of departments on an oilfield that determined the accuracy and co-operative usefulness of any records that were kept.

Mr. A. J. Ruthven-Murray said that with regard to the well history sheets to which the author referred, he thought that compiling the information on one main sheet would make the record rather unwieldly and, besides, it seems to him to be a duplication of records which should be found in their respective files under different headings. He himself had found that keeping a loose leaf book containing the essential and oft-required information appertaining to each well was the most useful. In that book was kept the total depth of the wells, depth at which each of the index marker horizons were found, depths of tubing and casing, etc ; then, if the well had been deepened, the amount and depth of junk side-tracked. Such a book formed a much better and handier

record than collecting all information on to one history sheet, which of necessity must be somewhat unwieldy.

He noticed Mr. Harris had made no reference to a paleontological record. They had been examining all their cores microscopically, which had been taken from the Cruse series, and recording graphically the different type forams found at varying depths; this, with the object of correlating the horizons passed through in wells, spread over different parts of the field.

Lastly, he wished to congratulate Mr. Harris for having called attention to a very important point which was so often overlooked, namely, that of separating fishing and other tools, grouping them together in their respective sizes and colouring them accordingly. A good deal of time was frequently wasted by having tools of one design but of different sizes stored together, rather than having all tools separated according to sizes of pin or box.

The Chairman said that the outstanding point in the paper was the declaration by the author that adequate and accurate compilation of past results afford the only basis for accurate estimates of future performances.

Everyone present appeared to agree with that particular point, but he would suggest that some forms could be eliminated. For instance, equipment location records could have no interest to future generations. The purpose of these returns could be more economically and efficiently obtained when left to an individual responsible for all plant and material of a movable nature.

He endorsed the point raised for consistency, even though at times it entailed perpetuating an error, otherwise in some cases the value of original records was lost.

The Author, in reply, said the original idea of this paper was to obtain criticism of its contents. That generally followed, as he felt himself that the paper was only an approximation to a perfect set of records, and he himself thought that a good purpose might be served by circulating the forms attached to the paper amongst those who were interested and asking for their criticisms on them.

Several members had drawn his attention to very obvious defects in the paper.

In the first place he quite agreed with Mr. Cooke that there should be some record relative to mud used. He thought it was quite a good idea to incorporate a record of that nature.

He agreed with practically all of Colonel Hickling's criticisms. He thought, however, that a topographical map was the only method of getting a sound idea of surface irregularities for areas of any size in forest country. Other methods of development

would be all right for small areas, but probably quite wrong for general development of an entire field. Balancing up errors on a series of piecemeal development was not always possible. He was inclined to agree with Colonel Hickling's views on battery gauging, and felt that individual well gauging was almost always justified.

With regard to Colonel Hickling's observations on his so-called group productions, he quite admitted it was a system of expediency, and such a system could not be defended on any absolute scientific grounds. To incorporate past field records, however, it was frequently necessary to introduce schemes which were empirical rather than scientific. The lines of demarcation between zones were not always as precise as could be wished.

He quite agreed with Mr. Toone that derricks should be included in the equipment index if they were steel, but not if they were wooden. On the other hand, the form he suggested did ensure that the state of the derricks on a field was brought to the managerial eye at certain times. Such a record ensured that accurate information about derricks was available. On older fields a large percentage of derricks were weak, and it seemed advisable that a statement of such derricks should be kept.

He thought Mr. Capito's remarks were quite sound. He agreed there were far too many records and there was a certain amount of duplication which could be avoided.

He thought his suggestion of putting Forms G.A. and G.B. on one sheet and simplifying the same a very good one, and he also agreed with him in his observations about referring to the position of wells by co-ordinates.

Mr. Scott referred to the possibility of uniformity of records as Utopian. The only justifiable goal of modern civilization was Utopia. He emphasised Mr. Scott's remark that the petroleum engineer was very much governed in what he did in the matter of records by what had been done by his predecessors. The apt simile was that the child was father of the man, but there was no reason why, on a new field, one should not bring up the child properly.

The colouring of sections was a very controversial point, and he did not think that uniformity of practice would ever be obtained; if only one or two sets of sections were required, colouring was possible; if large numbers were required, colouring did not seem advisable.

He agreed that the lines of the section should always be at right angles to the strike, and as far as he was concerned all sections were drawn on that principle.

He was sorry to see there had been no space for viscosity on the driller's report and that should be rectified.

The inclusion of information about bits on the driller's tour reports would probably not be very useful if one did not number the bits. He quite agreed, therefore, that the bits should be numbered.

He quite agreed, too, with regard to the keeping up of centrifuge figures as well as gauging figures for water.

He was not very much in favour personally with the keeping of well history sheets showing depth against time, but that was only a personal point of view. He quite realised that in certain circumstances the form would be quite valuable, and he absolutely agreed with Mr. Wilson that core recoveries should be recorded adjacent to the description of cores.

Mr. Bushe very kindly drew attention to the fact that if a wire-line record was used the number of round trips should be entered on the tour reports.

He thought Mr. Bushe's views with regard to fishing tools were very valuable.

Mr. Kirby brought up several points, amongst which he mentioned the question of the synchronisation of periods of production. Personally, he did not think it mattered what time of day the various companies stopped, or even if various fields of the same company stopped at different times.

He quite agreed that the loose leaf sheets for well histories were desirable. Gas/oil ratios used recorded the gas employed in lifting a barrel of oil.

Figures submitted as reserves of wells had naturally a degree of uncertainty, but their comparative value was fairly accurate. These figures were mainly valuable on comparative grounds, and those he submitted should be included in relevant records. He quite admitted that it was an estimate and could not be other than such.

Mr. Kirby brought up the important matter of ensuring that well histories were complete and accurate. The well history was based on the daily or tour reports. These reports were seen by the field manager, drilling superintendent and petroleum engineer, and should be amplified or corrected by all these officials (if necessary). If this procedure was followed the well history based on such corrected reports should be accurate.

He quite agreed with Mr. Murray that well histories or loose leaf sheets have much to commend them.

He also agreed that it was an omission that he had not referred to paleontological records, which should be kept.

The Chairman had pointed out the value of having a member of the staff with complete local knowledge on the field. He submitted, however, that adequate records were far more efficient,

safer and cheaper in the end. It was a definite unjustifiable risk to trust to one mind all this essential information. The lay-out of pipe lines, etc., should be made as simple as possible, and spare machinery should be withdrawn to salvage or a central machinery rack.

On the motion of the Chairman a vote of thanks was accorded the author for his paper, and to their hosts, the President and members of the Apex Club, for the use of the building.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

THE TWENTY-NINTH GENERAL MEETING of the Trinidad Branch of the Institution of Petroleum Technologists was held at the Apex Club, Fyzabad, on Wednesday, April 27th, 1932, Mr. A. F. DABELL, Branch Chairman, in the Chair.

The following paper was read :

Some Notes on the Mixing and Placing of Cement in Oil Wells.

By L. A. BUSHE (Member).

The use of cement now plays an important part in the production of petroleum. It is not proposed to deal with the several methods in which cement may be mixed, nor the many uses to which it is put, but to encourage a discussion by giving views on mechanical mixing and cementing generally.

MECHANICAL MIXING.

The following is a description of a cementing outfit which appears to be suited to conditions in Trinidad :—

The outfit consists of :

1. 10 in. × 4 in. × 12 in. or 10 in. × 4 in. × 10 in. pump for mixing cement.
2. 10 in. × 4½ in. × 10 in. pump for pumping the grout into the well.
3. Mixing hopper.
4. Water tank or tanks, capacity about 20 barrels.
5. Suction tank or box, capacity about 1 to 1½ barrels.
6. Valves or stop cocks and other fittings for pump manifolds, etc.

On fields where the derrick floors are set 6 ft. or more above ground, with roads alongside the derricks, the hopper is mounted, with the pumps and tank, on a four-wheeled chassis. The cement is sifted into a box or boxes on the derrick floor and either shovelled or fed through a gate into the mixing hopper.

For jobs where the outfit cannot be run alongside the derrick or where the derrick floor is not sufficiently high to allow of the cement being fed from the floor into the hopper, the hopper may be removed from the chassis and placed on the ground and the cement fed from sacks.

Of the two methods of feeding the cement the first-named is strongly recommended for the following reasons :—

1. As the cement is taken from air tight drums only two or three hours before it is mixed, the possibility of its becoming damp is reduced to the minimum—a very important detail in this climate.

2. The drums of cement can be handled with the cat-line, and the sifting is supervised by the driller.

3. A more regular feed is maintained by shovelling the cement or discharging it from a gate down a chute than is possible by dumping it from sacks.

4. Only two or three men are required for feeding the hopper, whereas at least eight men are needed if sacked cement is used.

Fig. 1 shows the lay-out when the cement is fed from the derrick floor, and Fig. 2 illustrates the detail of the outfit, particulars of the major units of which are as follows :—

Mixing Pump.—This is an ordinary general service pump, size 10 in. × 4 in. × 12 in. or 10 in. × 4 in. × 10 in., capable of putting up a pressure of 500 lb. per sq. in. Operating pressure is usually between 300 lb. and 400 lb.

Cement Pump.—Size 10 in. × 4½ in. × 10 in., fitted with brass liners and rubber sleeves. All-steel valves are recommended for this pump instead of the usual insert-type valve. A pump of this type has been used on jobs totalling 1286 drums of cement. The valves and seats show no sign of wear and the only replacements made have been eight rubber sleeves.

Mixing Hopper.—Fig. 3 illustrates the mixing hopper and shows four positions for the jet : " A," " B," " C " and " D." From the following experiments it appears that a jet setting approximating position " D " will give the best results, but it would be interesting to learn if anyone present has had experience of different jet settings.

Experiment No. 1.—The jet was set at " A " (*i.e.*, about 2 in. from the rear end of the mixing chamber), its size being ¼ in. × ⅝ in. for jobs of 25 drums or less and ⅜ in. × ⅝ in. for jobs greater than 25 drums. The axis of the jet lay at an angle to that of the mixing chamber, so that the water impinged on the bottom of the 6 in. × 3 in. swedge nipple. This arrangement worked well on small jobs, the mixing speed being as high as five drums of cement per minute, but it was found that the speed decreased considerably on jobs of over 25 drums due to caking of damp cement in the chamber and lower end of the hopper. On several jobs choking occurred at the commencement due to the cement being fed too fast. Jets of different sizes, both flat and round, were tried, but there was always this tendency to choke unless the job was started with a slow rate of feed. On the majority of these jobs the mix was far from uniform, the weight of the grout varying from 112 lb. to 126 lb. per cu. ft.

Experiment No. 2.—Various sizes of jet (both flat and round) were set at point " B " with the axes of the jet and mixing chamber coincident.

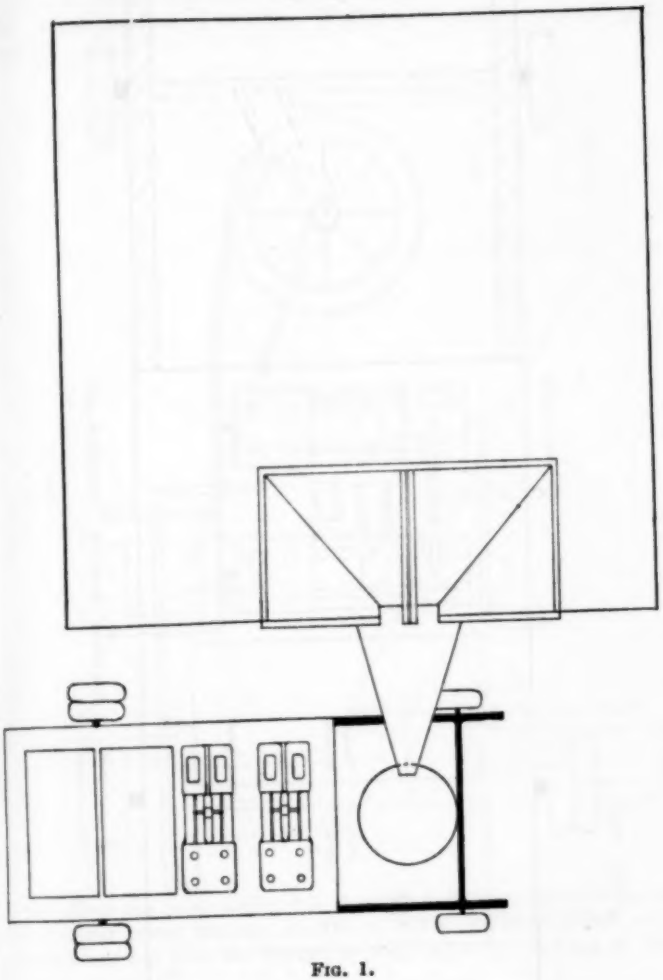


FIG. 1.

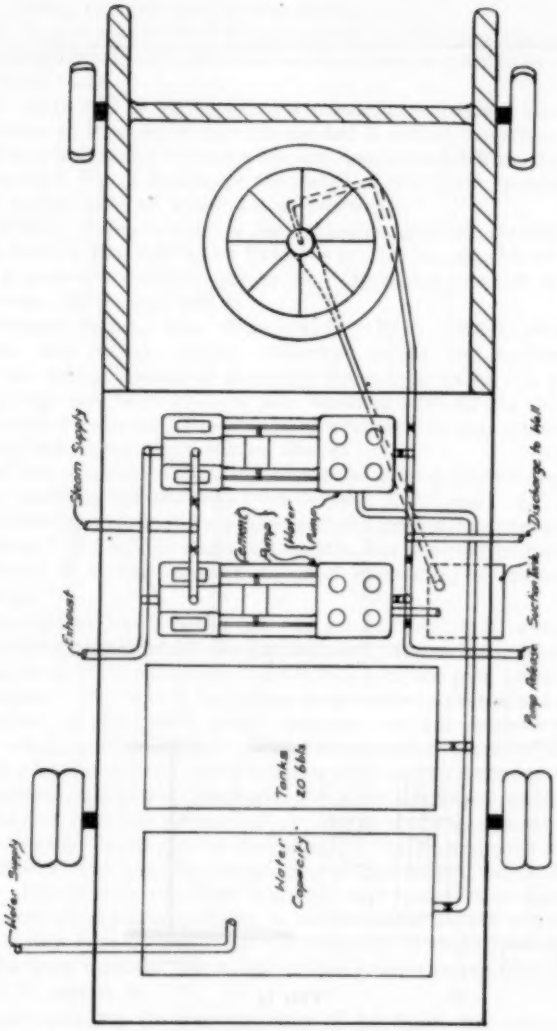

Steam Supply
Exhaust
Cement Pump
Water Pump
Discharge to Mill
Suction Tank
Pump Aducts
Tanks 20 bbls
Water Capacity
Water Supply

FIG. 2.

Results were slightly better than in the first experiments, the weight of the grout averaging 116 lb. per cu. ft. and ranging from 112 lb. to 120 lb., but there was still a slight tendency to choke at the commencement of mixing. Mixing speed was four drums per minute.

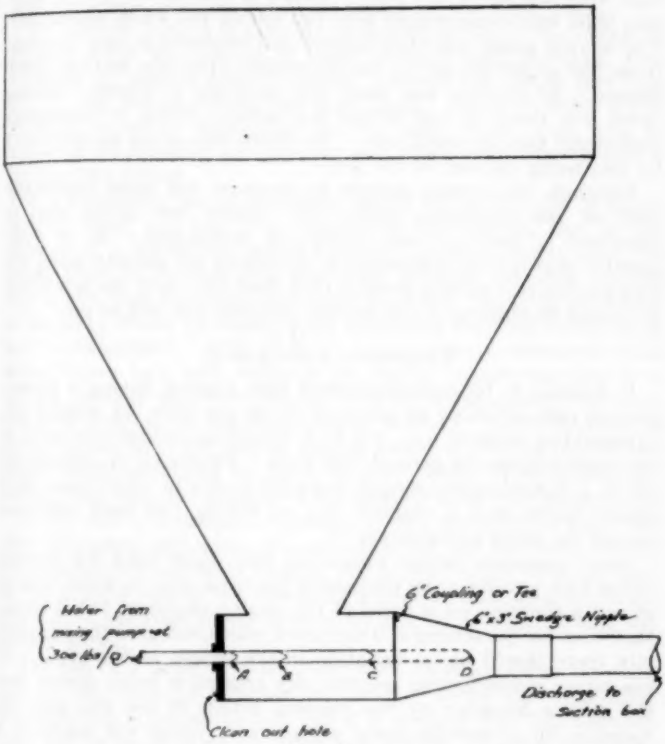


FIG. 3.

On all of the jobs carried out thus far it was necessary to have the mixing pump running at 200 to 300 lb. pressure before any cement was fed into the hopper in order to avoid choking of the mixing chamber.

Experiment No. 3.—A round jet of ¾ in. diameter has now been set at point " C " and results have been such that it is proposed to

experiment still further, for it appears that the best position for the jet is probably at or near to point " D."

Three cementing jobs (a total of 51 drums of cement) have been carried out with the jet at " C " and there has been a variation of only 4 lb. per cu. ft. in the weight of the grout, the average being 118 lb. In each case the hopper, mixing chamber and discharge pipe were absolutely dry before mixing commenced. The hopper was filled with cement (and kept full during the whole operation). The mixing pump was then started and operated at any pressure from 200 to 500 lb. per sq. in. depending upon the mixing speed desired. At no time was there any tendency to choke. Mixing speed was three to four drums per minute, which is considered sufficiently fast for small jobs. No doubt this could be improved by increasing the size of the jet.

Although the mixing hopper is, perhaps, the most important part of the cementing outfit, the author has never seen it described in detail in any article on cementing. It is quite possible that several companies in the Island are already using the long jet, but it is equally possible that short jets, with the attendant proneness to choking of the mixing chamber, are still in use.

Cementing Generally.

It appears to be generally agreed that a grout having a water/cement ratio of about 40 per cent. to 45 per cent. by weight (or, expressed in another way, 4·5 to 5 American gallons per sack) is the most suitable for general well work. Expressed in pounds per cu. ft. a suitable grout weighs from 118 to 121 lb. and it has been shown above that a uniform mix of 118 lb. has been obtained during the latter experiments.

Some operators favour measuring the water used for mixing either with a meter or by calibrating the tank, and on some cement mixers a thinning jet is fitted to the mixing chamber, but it seems that once the jet setting is determined which will give the required mix there should be no variation in the weight of the grout. If the mixer is functioning properly dry cement is being drawn into the mixing chamber by the vacuum action of the jet, and the speeding up or slowing down of the water pump will result in a corresponding increase or decrease in the rate of mixing. The weight of the grout should remain fairly constant.

Having decided upon, and obtained, the cementing outfit most suited to one's needs, it only remains to place the cement grout at the desired depth as quickly as possible. As this applies to all cementing jobs, only the most common will be dealt with, that is the cementing of casing by the two-plug method.

Immediately before mixing commences, from five to ten barrels

of water are pumped into the well. It is probable that this water does not travel down the casing in the form of a slug and wash clean the wall of the hole, but at all events it will thin up the mud which is in close contact with the cement and allow a better bond than would be the case were it not used.

The bottom plug, cement grout and top plug are then put in and the whole pumped down the casing by the slush pump.

On shallow jobs it is strongly recommended that the casing be rotated while the cement is being pumped past the shoe, thus ensuring at least a film of cement between the casing and that side of the hole to which the pipe hangs. On deep wells, where rotation is either impossible or too risky, some good will be achieved by working the pipe up and down while the cement is leaving the casing.

If a measuring line is used there should be no difficulty in determining when the top plug reaches its destination, but in the absence of a measuring device pumping should continue until the pump stalls or at least until the pump pressure indicates, beyond any doubt, that the plugs have come together. Gauging the travel of the plug, either by timing or by measuring the fluid, is definitely not recommended. Both of these methods are so inaccurate that should there be a leak, either in the casing or past the plug, it is almost certain that the cement will be contaminated by mud before a decision to stop the pump is reached. If the operator is in any doubt as to the slug of cement having arrived at the desired depth uncontaminated by mud, it were better to re-cement the casing than that the efficacy of the shut off should be jeopardised.

In the case of a conductor string it is only necessary to lower the pipe to bottom and allow the cement to set, but for water strings or combination oil/water strings, the pump should be connected to the annulus outside the casing and a pressure built up to minimise the risk of agitation of the cement by gas, oil or water during the setting period.

The use of a baffle or float collar some distance above the shoe (or, in the case of combination strings, above the cementing perforations) is recommended, but it is thought that this distance need not be as great as the 10 ft. per 1000 ft. of casing suggested by several authors. For casing strings of average length in Trinidad it is believed that 10 ft. per 2000 ft. of casing is ample to take care of the laitance or washed cement, provided that the grout has a water/cement ratio not greater than 45 per cent. by weight. In this connection a combination oil/water string of 8¾-in. casing was recently cemented at 2800 ft. with a baffle 12 ft. above the cementing perforations. After the cement had been allowed to set for four days, plugs were drilled out and a core taken

of the cement below the plugs. Although full recovery was not obtained, the core barrel brought up about 2 ft. of hard cement, and the driller reported that he had to put about three points (6000 lb.) weight on the core barrel in order to take the core.

The advisability of using an ordinary Portland cement with an accelerating re-agent rather than a quick-hardening cement is largely one of opinion. Weighing the advantages and disadvantages of the two, but without considering scientifically the effects of temperature and other variable factors, the author is in favour of the quick-hardening cement. In Trinidad, on a price comparison, the odds are slightly in favour of the accelerator, but the difference, about 45c per drum, is too small to be considered.

In conclusion it has been proved, in some fields, that by a more frequent use of the core barrel in conjunction with loaded mud, one string of casing may be set where formerly two or more were employed. But this can only be done in safety by a more extensive use of cement, and it is felt that a small portion of the money saved in casing would be well spent in experimenting with a view to effecting improvements in cementing practice and so reducing the number of failures of cementing jobs."

DISCUSSION.

Mr. C. E. Capito said he was very much in agreement with the author's arrangement for pumping five barrels or more of water down ahead of the cement and personally he thought most strings could have at least 100 ft. of water put in with impunity, provided the mud was heavy enough to keep the well quiet, that was 100 ft. of the annulus that was to be filled up with grout.

He had always adopted the principle of moving casing up and down during cementing jobs ; rotation, of course, was good where one could rotate.

He could not understand the author's objection to measuring the liquid following the top plug. Personally he thought that that was the safest method of checking up where the top plug was. The measuring device might go wrong and he had known of several cases in Trinidad where the pumps had stalled with most of the cement in the casing and little having gone out at all.

With regard to the calculations, he had done a large number of cementing jobs, mostly through tubing he admitted, and had calculated the quantity of liquid to go down behind the cement and had only been 2 or 3 ft. out at any time. It certainly meant a little trouble to measure up the pipe from the suction valve to the bottom of the hole, or wherever the cement was going to be put, but in most cases where a standard outfit was used the only variable was the volume of the string to be cemented.

With regard to the decision to stop, the Area Superintendent used to be in charge of the gauging, and the Area Engineer took charge of the pump, and as soon as the gauge showed they were getting near the end of the liquid the pump was slowed down and it did not take very long to shut it down.

On the question of leaving cement in a string, he thought it was at times useful to do so in rotary drilling, but he did not think it was necessary in a water string, where a float valve was fixed at the bottom ; but in a combination string where the outlet for the cement is above the valve he thought at least 20 ft. of cement should be left in the string.

Mr. A. J. Ruthven-Murray said with regard to cement pumps he used a 10 in. × 3 in. × 10 in. pump for mixing which was capable of developing 1500 lb. at 175 lb. steam pressure. He thought that success in the suggested method of mixing would depend to a considerable extent on the pressure put up by the mixing pump. He used a pressure of over 600 lb. and obtained an even mix, the grout weighing from 116–120 lb. He had experienced no trouble at all, though he had done jobs using up to 120 drums of cement at a time, mixing this in 27 minutes ; he used a $\frac{5}{16}$ in. jet in the position " A."

With regard to the pump used for putting the grout into the casing, this is done with a 10 in. × 4 in. × 10 in. pump capable of developing 500 lb. pressure.

He was impressed with the form of box which Apex (Trinidad) Oilfields, Ltd., used for storing their cement prior to placing it into the hopper. It seemed a good arrangement for obtaining an even flow of cement to the hopper and thus materially assist in getting an even grout.

He was interested in the experiments made with the jet in position " C," because they seemed to have obtained a much more even grout than with the jet in positions " A " and " B." Naturally the regular feeding of the cement into the hopper was an important factor, and the keeping of an even water pressure through the jet when once mixing has commenced.

He had noticed that Apex (Trinidad) Oilfields, Ltd., placed their cement storage box on the derrick floor ; that was possibly due to the way in which Apex built their rigs, as they did not appear to allow for the installation of a standard tool end. They placed the cement box on the side above the road and usually instal their rotary draw-works on the left-hand side ; this enabled the cement outfit to be on the road below the box.

Mr. Murray said that in the Kern Co. they installed their rotary draw-works in the position where Apex Co. temporarily placed the box, this in order to allow the installation of a standard tool

end to the left. This method of rigging up made the use of a box impossible, unless it could be mounted on the road clear of the derrick floor; he believed that several other companies would be faced with the same difficulty.

In their particular hopper they had an extended throat on the bottom of the V mouth, this throat being a 12½ in. × 6½ in. swedge nipple, which is screwed into a 6 in. elbow, the $\frac{5}{16}$ in. jet being fixed in this elbow which in turn was connected to a 6 in. × 4 in. swage to a 4 in. line pipe discharging into the suction box; rather a different design to Apex.

He was impressed with the idea of the jet in position "C" or "D"; theoretically it looked excellent, and he was going to see if they got better results than those obtaining at present. When cementing water strings, they usually ran a float collar one joint up from the shoe and then used a single plug, unless, of course, it was a combination job.

He, like Mr. Capito, was in favour of pumping down approximately five barrels of water ahead of the cement. The idea of building up a pressure on the annulus outside the casing to minimise the risk of agitation was good, but surely that would only be done when cementing a water string before drilling into the main oil sand, otherwise it seemed that there would be a risk of the cement being pumped down into the oil sand.

He did not quite follow the statement, referring to the baffle: "In this connection a combination oil/water string of 8⅝ in. casing was recently cemented at 2800 ft. with a baffle 12 ft. above the cementing perforations." He presumed that must be a perforated baffle. The method they usually employed was a float collar, or in the case of combination strings a solid baffle placed below their cementing perforations.

Mr. Bushe: This was a perforated baffle.

Mr. Murray, referring to the statement in the ultimate paragraph, said he did not agree that 45c. per drum was too small to be considered; they had frequently used 100 drums of cement on a single job, and it was likely that times would arise when much more would have to be used; and he thought, especially at the present time while crude is selling for such a low figure, that $45 on 100 drums was well worth saving.

Mr. J. D. Fullerton said the Author had pointed out that it was very important to rotate if possible or to move the casing up and down so as to get the cement all round the annular space, and that Mr. Cooper Scott mentioned having used a device for bringing the shoe central in the hole. It occurred to him that there might be considerable scope for the use of an

under-reamer or eccentric bit where the setting depth of the casing was definitely known beforehand. If the last 15 or 20 ft. of hole was drilled with an eccentric bit, or was under-reamed to a diameter 4 in. or 6 in. greater than the normal size of the hole, it followed that the shoe would be held clear from the wall of the enlarged hole, thus ensuring a complete sheath of cement around the shoe joint.

Mr. J. W. Knights said he thought that a great improvement had been accomplished in the mixing of cement by the suction jet (Experiment No. 3), chiefly because of the maintained weight of the grout. At first he was against it because the first time it was used it completely choked, the reason being that the hopper had been used to put the first influx of water into the well, and contamination resulted, and when the cement was used it held up in the hopper. The most essential point was that the hopper must be kept dry, and he would like to suggest that a cylindrical lid be fitted so that the hopper would be dry in all weathers, and in addition a flap could be made to fit the chute. This lid would be a guarantee that all the cement went into the job and not as happened at present when there was a heavy wind, some of the cement being blown away; also a heavy handed feeder often ran the cement over the brim.

Another very important point in cement work was the cleaning of the mixer and fittings thoroughly after each job, even to the scaling of the hopper and suction ejector pipe, though with Experiment No. 3 there did not seem to be the need to scale the hopper as with the push jet system (Experiments 1 and 2).

Mr. A. H. Richard congratulated the Author on his extremely lucid and sensible paper. To him the position of the jet was extremely interesting. Particulars and details of the position of the jet for various other purposes were known; for instance, the laboratory vacuum pump, the water pump and boiler feed injector and sand injectors; and it was extremely interesting to him to see how the conditions could be modified and made applicable to a case where an entirely different material had to be handled. He thought it was a matter upon which a great deal more experimental work could be carried out. Personally, he was, theoretically, in favour of position "D" as shown on Mr. Bushe's sketch. Of course, it might not prove the best position for a material like cement, in practice.

He had recently seen an article describing boiler feed water injectors for locomotives, and one thing there struck him which might possibly be suitable for use in cementing. They had a double jet, one called the lifting jet for lifting water into the nozzles

and the other the forcing jet, and it seemed that possibly it might be an advantage to have a double jet in their case. The first jet would be what he would term the mixing jet and the second the forcing jet. It struck him when Mr. Cooper Scott mentioned the fact that they required considerable force to move the grout along that a combination of the two jets might improve matters.

As regards the position of the baffle, the Author recognised that much less clearance need be provided than was used in America. Of course that might be accounted for by slightly different methods. In America they apparently believed in putting all the cement in, whether it was thinned up or not and that might account for their recommendation of greater clearance from the bottom of the casing.

It occurred to him that if it was a matter of importance it could fairly easily be determined by laboratory tests by making various mixes of cement and holding them under pressure for the time they would be required to set in the casing. In that way one could determine, within the limits required, the amount of clearance necessary to take care of the laitance.

Mr. G. A. Richards said that there were two objections the Author did not mention to the measuring of mud. One was that mud which was slightly gas cut might have to be used and in such a case measuring the mud was of no use at all. In the other case when mud was measured from an ordinary mud pit it was generally found that the walls were not vertical, and if mud was taken from the bottom, and the area of the mud pit was measured at the surface it was also impossible to obtain really accurate measurements of the volume of mud used.

Of course relying upon the pumps stopping when the plugs hit was not entirely satisfactory, because there was the possibility of wooden plugs splitting. Rubber plugs had been used with success, the chief drawback was that they are rather expensive, but it was impossible to pump past them.

Mr. J. L. Harris said he thought one point which the Author stressed which was peculiarly important was the method of placing the cement in the hopper. He should say that almost anything was better than placing the cement in sacks as this practice must lead to a tendency towards the deterioration of the cement due to the time which necessarily elapses between the sacking and the use of the cement.

Another important point which Mr. Bushe did not mention and which was not commented on was that good cement practice must lead in the end to elimination of strings of casing which, he believed, should be the tendency of all economical drilling procedure.

He would like to ask Mr. Bushe if he had any experience of failure with the cement nozzles in positions "A" and "B," presumably he had not had any at "C" and he had not attained to the position "D."

Mr. Cooper Scott referred to the centering device at or near the shoe of the water string, he also suggested that it was more valuable than passing collars or turning the pipe.

With regard to measuring the amount of fluid pumped after the top plug he was afraid he must support Mr. Richards and Mr. Bushe, but, of course, there was the alternative that if you mixed enough cement to reach to the surface you would know your plugs were in position when the returns indicated a large percentage of cement.

Mr. H. D. Fletcher said the points that struck him were Mr. Cooper Scott's remarks about high pressure and Mr. Knight's remarks about keeping the inlet or the neck of the hopper and the mixing chamber as dry as possible. This was no doubt the best way to prevent the hopper from choking up in doing long cementing jobs. The further one went beyond the neck of the hopper ensured a more successful operation, as with too short a jet no vacuum resulted and this led to the cement building on the walls of and choking the mixing chamber.

If the pressure was too low, the water would run back and moisten the walls of the mixing chamber so that the cement would build up, gradually restricting the area and so retard the rate of mixing.

Mr. H. W. Reid said that there was one point the Author might have mentioned under the "Advantages of Box and Chute Feed," namely, the saving of expense in not having to sack the cement.

In regard to experiment No. 1, in which the weight of the grout at times was up to 126 lb. per cu. ft., he would like to ask whether this heavy grout was maintained for any appreciable time, say, for one or two minutes, and, if so, whether there was any difficulty in handling it with the pump?

The Author referred to the practice of pumping in 5 or 10 barrels of water ahead of the cement. This practice and the use of as little mixing water as possible were of paramount importance.

Doherty and Manning,[1] as a result of their experiments, stated that the principal cause of defects or failures in the cements which they had examined in cores was contamination by drilling muds. They said that small amounts of mud could do considerable damage, and, other things being equal, equivalent mud contamination was greater with a thin grout than with a thick grout. They

[1] *Oil & Gas J.*, Sept. 11, 1930.

recommended, if it was safe, that the cement be allowed to set in pure water, but where this was unsafe as much as 20 to 30 barrels of water should be pumped ahead of the cement, claiming that small amounts of mud seemed to prevent the settling of cement particles, thus causing the cement to be very weak and highly porous. Their experiments showed that for a 50 per cent. by weight grout, the tensile strength of briquettes at the age of three days decreased from 188 lb. per sq. in. for 1 per cent. mud contamination to 100 lb. for 15 per cent. contamination.

Reid[2] showed that for a 40 per cent. grout the decrease was from 320 lb. per sq. in. for 1 per cent. mud contamination to 168 lb. for 15 per cent.

These experiments showed the importance of pumping water ahead and maintaining as thick a grout as possible.

The Author briefly referred to the relative merits of quick hardening brands of cement and ordinary Portland cement with accelerators. The following figures in connection with experiments the writer had carried out some time ago may be of interest, but it should be borne in mind that the number of the experiments was possibly insufficient to be used except as a rough guide.

A number of briquettes were made of a 40 per cent. grout and were broken after three days. Ordinary Portland cement, treated with varying percentages of calcium chloride as an accelerator, gave the following results, taking the strength of the quick hardening cement as 100 per cent. :—

Mixing Water Containing.	*Strength in Percentage.*
1% $CaCl_2$	86%
2% „	94%
3% „	99%
4% „	105%
6% „	129%

Mr. E. G. Rooks said he suggested that, if a measuring device was being used, a plug of water should be pumped in behind the top plug, so that the small weight would be going down in water and not in heavy mud. In a few cases he had seen the measuring device fail to register accurately, and he thought it was affected by the heavy mud in travelling down.

Mr. J. M. Penny said that a good deal of reference had been made to the position of the jet in the cement hopper, but little had been said about the relative values of jets of different sections. The Author had mentioned that the types of jet mostly used were either round or flat in section at the tip. He would like to ask the Author whether he had ever made use of a jet which would

[2] *J. Inst. Petr. Techn.*, 1932, **18**, 53.

impart a whirling motion to the stream of mixing water. It seemed to the speaker that this whirling motion would definitely contribute to the efficient mixing of the grout as a result of the centrifugal action which would take place within the confined space of the mixing chamber and outlet pipe therefrom.

Reference had been made to the fact that the Halliburton Cementing Co. made use of the unusually high nozzle pressure of 800 lb. per sq. in. The speaker considered that this fact could be attributed to the exceptionally large amounts of cement mixed in a very short space of time by the Halliburton Process of cementing, amounts probably considerably in excess of any employed on cementing jobs done in Trinidad.

He would like the Author to give his opinion as to how effective a bond was made between the walls of a well which had been drilled with heavy barytes-laden mud and cement which might be pumped into the well for cementation of casing; and, moreover, did the Author consider that, where practicable, a thorough reaming of the hole just prior to insertion of the casing would increase the possibility of as nearly a perfect bond as could possibly be obtained being effected between the cement when it had set and the walls of the hole with which it came in contact?

The Chairman said that where cementation was inevitable he would suggest to those who wished to reduce their risk that a single plug to follow the cement down only be used, and where time was of minor importance still further reduction of risk would result from the elimination of the accelerating medium.

The Author acknowledged that under the best practice bond between the casing and wall of the hole was rarely attained, therefore, it followed that the indiscriminate call for the use of cement was based upon a fallacy.

The Author, in reply, said that Mr. Capito suggested pumping in sufficient water ahead of the cement to fill about 100 ft. of the annulus instead of 5 to 10 barrels as mentioned in the paper. The Author agreed, and pointed out that with the usual clearance (such as when setting $6\frac{5}{8}$-in. casing in $9\frac{3}{4}$-in. hole or $8\frac{5}{8}$-in. in $10\frac{1}{4}$-in. hole) 10 barrels of water would fill more than 100 ft. of the annulus.

Mr. Capito considered that measuring the fluid was probably more effective than using a measuring line, but with this the Author could not agree. As Mr. G. A. Richards pointed out, it was probable that the mud contained a fair percentage of gas so that it would not occupy the same space in the slush pit as it did in the hole. Besides the possible error in calculation from this cause, should there be a leak either past the plug or in the casing, the operator would not know when to stop the pump, and the result would be contamination of the cement by mud.

Mr. Capito asked if a float plug would not serve the same purpose as a baffle. The idea of the baffle was to stop the plugs some distance from the bottom of the casing. This a float plug would not do as it is screwed to the bottom of the string. A float collar, on the other hand, would take the place of the baffle, as it could be inserted at any point in the casing string.

Mr. Murray stressed the value of a high mixing pressure, and the Author agreed that it was important if a short jet were used. Mixing 120 drums in 27 minutes was a very creditable performance, but Mr. Murray did not tell them what weight of grout he got.

Mr. Murray: An average of 117 lb. roughly.

The Author, continuing, said that was very good, but he thought Mr. Murray might have had equal success with a lower mixing pressure had his jet been differently placed.

Mr. Murray raised the point that cement could not be fed into the hopper from the floor of standard rigs. He thought he had made provision for that in his paper by saying that if the cement could not be fed from a box on the derrick floor, the hopper could be placed on the ground and the cement fed from sacks.

He could not see that any benefit would be derived from having a throat in the hopper, though he confessed that he had not experimented with a hopper of this design.

Several gentlemen had referred to the use of a single cementing plug. He was definitely not in favour of this except when cementing through tubing. When cementing casing with one plug there was nothing to prevent the cement from being contaminated by the mud which was already in the casing.

He thought putting a pressure on the outside of the casing was useful, even in the case of combination oil/water strings. It was quite possible that water, oil or gas had been encountered above the oil sand from which production was to be obtained, and it seemed to him quite important to prevent agitation of the cement by this water, oil or gas. He did not think there was any danger of forcing cement past the cementing perforations into the oil sand. Obviously, if it was found that the formation was taking fluid, the pump would be stopped at once and for that reason he did not mention any pressure in his paper. He had frequently found that the formation would take fluid at 100 lb. to 200 lb. pressure, but he thought that even this small additional pressure would help to prevent agitation of the cement during the setting period.

Mr. Murray did not think that 45c per drum (the additional cost of using a quick-hardening cement instead of ordinary Portland cement with an accelerator) was a negligible amount. The Author's view was that the time and trouble entailed in mixing

carefully the accelerator for every cementing job would more than offset the additional cost of the quick-hardening cement.

Mr. Cooper Scott in dealing with pressures for mixing, thought that 800 lb. was probably a good figure. He also considered that the position of the jet did not matter as long as the right pressure was used.

The Author said he had not used a mixing pressure as high as 800 lb., but he thought that the position of the jet was of great importance no matter what mixing pressure was used. If the jet is set back either in position "A" or "B" a certain amount of splash must take place in the mixing chamber. By setting the jet forward this is overcome and good uniform grouts are obtained with a mixing pressure as low as 200 lb.

With regard to centering the casing in the hole, the Author agreed that such a device would be useful if there was plenty of clearance between the shoe and the wall of the hole. But as the outside diameter of a casing shoe is considerably greater than that of the casing there must always be room for some cement in the annulus even on that side of the hole to which the casing hangs.*

Mr. Fullerton also mentioned the centering device and suggested using an under-reamer or eccentric bit before running the casing in order to provide additional clearance for the shoe. If sufficient clearance had not been cut with the original bit it would certainly be necessary to ream the hole before attempting to insert the casing, but the Author thought this practice should be avoided as much as possible as, besides being costly, it might in some cases expose high pressure gas sands which had been successfully mudded off during drilling.

Mr. Knights suggested: (1) that the hopper should be provided with a cover, and (2) that the cement outfit should be thoroughly cleaned after every cementing job. The Author agreed on both points.

Mr. A. H. Richard thought it might be possible to apply the use of two jets (one for lifting and the other for forcing) to the mixing of cement. The details of such an arrangement could not be dealt with now, but the Author thought it would be necessary to provide another pump or alternatively a large one with some method of regulating, independently, the feed to the two jets.

Mr. Richard also suggested that it might be possible to determine the amount of laitance that takes place during a cementing job by laboratory experiments. The Author referred to the theory put forward by one writer that laitance is caused by turbulence of the cement while it is being pumped down the casing, thus causing settling out of the cement particles. He thought it would be difficult to obtain this condition in the laboratory.

Mr. G. A. Richards pointed out the possibility of error in trying to determine the travel of the plugs by fluid measurement, and the Author was grateful for his support in this direction. He also suggested using rubber cementing plugs. Besides being more costly the Author thought they would be more difficult to drill up than wood plugs, but Mr. Richards assured him that such was not the case.

Mr. J. L. Harris' opening remarks contained nothing but praise, for which the Author was duly grateful. He then asked if any failures had been experienced with the jet in positions "A" and "B." The Author said that in a few cases a re-cementation had been necessary owing to partial choking of the mixing chamber, resulting in a very thin grout. No failures had occurred with the jet at position "C."

Mr. H. W. Reid's query regarding the cost of sacking cement, the Author said he had no figures to put forward. If much sacking is done the cost should certainly be considered, especially in such a climate as this where, if for any reason the cementation was delayed, it might be necessary to re-sift the cement. Mr. Reid referred to the grout of 126 lb. per cu. ft. mentioned in the paper, and the Author explained that weights were obtained almost continuously while mixing was in progress. A grout of 126 lb. was not maintained, but he thought the pump would have difficulty in picking up a grout of that weight for any appreciable length of time.

Mr. E. G. Rooks suggested pumping down a slug of water behind the top plug in order to assist the measuring line to follow the plug. The Author said he had seen this suggested in an article quite recently, and he intended to adopt it.

Mr. Penny suggested using a whirling jet. The Author said he had never tried such a jet and Mr. Cooke said he had tried it but results had not been satisfactory.

Mr. Dabell and Mr. Penny both asked what assurance there was of a bond between the cement and the wall of the hole. The Author pointed out that although a bond could not be ensured, he thought that pumping in water ahead of the cement, in cases where heavy mud was being used, was certain to have a beneficial effect. In the course of his remarks Mr. Dabell argued that the use of cement was not a *sine qua non*. The Author's answer was that as they were called upon to use cement he thought their aim should be to use it in the best manner possible.

On the motion of the Chairman a vote of thanks was accorded to the Author for his paper and to their hosts the President and Members of the Apex Club for the use of the building.

CORRESPONDENCE

The Analysis of Hydrocarbon Oils.

To THE EDITOR. Delft, November, 1933.

SIR,—The paper of R. H. Griffith and H. Hollings on the analysis of hydrocarbon oils (*J. Inst. Petr. Techn.*, 1933, **19**, 701) interested us very much, as the values for the aniline points of paraffins and naphthenes given in this paper (Fig. 2, p. 703) allow a comparison with our results on this subject. We wish to communicate the result of the comparison. As to the aniline points of paraffins and naphthenes there appeared to be good agreement; however, we have come to the conclusion that as to the naphthenes the agreement is only accidental.

In the following it will be shown that the naphthenes prepared by Griffith and Hollings still contain aromatic rings as well as paraffins (paraffinic side-chains).

In our paper (*J. Inst. Petr. Techn.*, 1932, **18**, 735-750[1]) a graph is given showing the relation between the aniline point and the molecular weight for paraffins and naphthenes in lubricating oil fractions. For the paraffins we used Carpenter's values, for the naphthenes the aniline points were calculated from the aniline points of completely hydrogenated oils (aromatic-free) of known composition. (The composition of aromatic-free hydrocarbon oils, *i.e.*, the percentage of naphthene-rings and paraffins, can be calculated from the specific refraction and the molecular weight.) This work has since been extended to the lower fractions and the values for the aniline points have been improved.

(*a*) *Paraffins.*—Like Griffith and Hollings we found Carpenter's values for the paraffins too high, and find rather good agreement with their values. This is shown in the following table :—

Boiling point.	Molecular weight.	n_D^{20} (G. and H., p. 706).	d_4^{20} (G. and H., p. 704).	$\frac{n^2-1}{n^2+2}\frac{1}{d}$ G. and H.	Theory as the average molecular weight.	Aniline Point (°C.). (G. and H., p. 703.)	Our values at the average molecular weight.
160–180°	135–147	1·4170	0·7368	0·3413	0·3404	75·0	75·4
180–200°	147–160	1·4208	0·7465	0·3396	0·3395	77·7	78·4
200–220°	160–174	1·4254	0·7566	0·3382	0·3386	80·6	81·8
220–240°	174–188	1·4301	0·7658	0·3374	0·3379	83·5	85·2
240–260°	188–204	1·4346	0·7756	0·3362	0·3373	86·7	88·5
320–340°	258–278	1·4578 (25°C.)	—	—	—	98·3	101·7

From the constants given by Griffith and Hollings we calculated the specific refractions and compared them with theoretical values.

[1] Compare also J. C. Vlugter, *Thesis Delft*, 1932.

As Griffith and Hollings did not give molecular weights, we derived these from the boiling range,[2] using Carpenter's boiling points for normal paraffins. A difference of 10° C. in the boiling range corresponds to 1·5° C. in aniline points. It is seen that the agreement is rather good. Griffith and Hollings therefore seem to have been successful in preparing these paraffin mixtures.

(*b*) *Naphthenes.*—The constants given by Griffith and Hollings have been collected in the following table. Specific refractions have been calculated by us :—

Boiling range °C.	n_D^{20} (G. and H., p. 706)	d_4^{20} (G. and H., p. 705)	$\frac{n^2-1}{n^2+2}\cdot\frac{1}{d}$	A.P., °C. (G. and H., p. 705).
230–240	1·4670	0·8494	0·3267	47·7
240–250	1·4786	0·8568	0·3307	47·0
250–260	1·4830	0·8624	0·3312	47·2
260–270	1·4866	0·8713	0·3299	47·7
270–290	1·4903	0·8790 (calc.)	0·3291	50·6 (calc.)

Molecular weights were not given but, for the first four fractions, in connection with the boiling range, can be estimated at about 180-200. It is remarkable that the above aniline points do well agree with ours. The aniline point of a naphthene without side chains (100 per cent. ring naphthene) of molecular weight 180-200 is derived by us at 45-50°.

However, the above specific refractions are considerably too high for 100 per cent. ring naphthenes. Assuming the polycyclic 6-carbon ring naphthenes without side chains the specific refraction at the molecular weight of 190 ought to be 0.3135. In fact the specific refractions agree with those of the monocyclic naphthenes C_nH_{2n} (rd=0·3294). In this case, however, the refractive index as well as the density are much too high,[3] the aniline points much too low, which indicates the presence of aromatic rings. So the naphthenes of Griffith and Hollings contain :—

1. Paraffinic side chains, which increase the specific refraction and also increase the aniline point ;
2. Aromatic rings, which also increase the specific refraction but lower the aniline point.

The resulting aniline points of these mixtures accidentally agree with those of the 100 per cent. ring naphthenes, but the too high

[2] J. Carpenter, *J. Inst. Petr. Techn.*, 1928, **14**, 461.

[3] Compare for instance the values of the monocyclic naphthenes isolated from petroleum hydrocarbons by Mabery (Beilstein V., 4th ed., p. 59).

	Molec. weight	Boiling point (°C)	n	d^{20}	$\frac{n^2-1}{n^2+2}\cdot\frac{1}{d}$
$C_{13}H_{26}$	182	228–230	1·444	0·8087	0·3285
$C_{14}H_{28}$	196	244–248	1·449	0·8099	0·3312
$C_{15}H_{30}$	210	—	1·452	0·8192	0·3293

specific refractions clearly indicate a considerable percentage of paraffinic structures and aromatic rings.

Attention may also be drawn to the fact that the few naphthenes presented by Griffith and Hollings have all been prepared from one oil—*i.e.*, Borneo oil. We are not convinced that other types of oil, say, American gas oil, when undergoing the same treatment, would give " naphthenes " of exactly the same composition.

J. C. VLUGTER.
H. I. WATERMAN.
H. A. VAN WESTEN.

To THE EDITOR. October 24th, 1933.

SIR,—We have pleasure in adding the following observations to the discussion on Dr. Kugler's most interesting paper on Sedimentary Volcanism (*J. Inst. Petr. Techn.*, 1933, **19**, 743–760). The Clay Pebble Bed of Ancon, Ecuador, rarely contains oil in any quantity and never water, though it is usually associated with gas. Large quantities of grit and sand are usuallydisseminated throughout the formation.

The chief objection to the injection theory of the origin of this deposit is its large extent, as it is known to exist over an area of 100 square kilometres and probably more. The main Clay Pebble is of Eocene age, but there is reason to believe that this type of deposit is not confined to one geological horizon only, as similar accumulations of probably Oligocene age have been recognised in the area.

With regard to Mr. Murray's remarks it is an exaggeration to say that the Clay Pebble Bed is slickensided throughout, and although this phenomenon is present, and has been caused by the incompetent nature of the rock material, it by no means characterises the formation. The Tertiary strata below the Clay Pebble are not similar to the Socorro Beds, as they contain far more sand in proportion to the shale, and the sands themselves are of a totally different nature. The micro-fauna of the lower beds is also easily distinguished from that of the Socorro Beds. It is of interest to note that the foraminifera characteristic of the formations below the Clay Pebble occur seldom, if ever, in the Clay Pebble itself, its fauna being more closely related to that of the overlying beds.

The formation also contains blocks of Orbitoidal limestone, lavas, quartzites and other foreign boulders which were probably derived from beds denuded or destroyed during its accumulation, for many of these types are found neither in the Socorro series nor in the lower beds.

Mr. Cedric C. Wilson mentions the occurrence of chert boulders in the Clay Pebble Bed. We have never seen chert in this deposit, and it is rather important to comment upon this, as large outcrops of chert rock are common in the Peninsula of Santa Elena, but they are newer than the Clay Pebble.

The thickness cited by Mr. Halse has many parallels in the Ancon area of Santa Elena (properties of the Anglo-Ecuadorian Oilfields, Ltd.), and these show that they cannot be accounted for by vertical dykes in the manner suggested by Dr. Kugler.

In conclusion, one would like to call attention to the remarkable photographs of one of the enormous mud flows noted by Dr. Roy Chapman Andrews which occur at the foot of the Boga Bogdo Mountains of Central Asia (see "The New Conquest of Central Asia"). From the physiographical aspect of these huge fans of denuded material they would appear to be a likely modern equivalent of the conditions which gave rise to the Clay Pebble formation of Ecuador in Tertiary times. This instance supports the view of Mr. Halse as to the necessity of desert conditions for the phenomenon. Professor F. P. Shepard (*Geographical Review*, Vol. XXIII., 1933), in his work on submarine valleys, etc., refers also to the possibility of landslides on, or near, the coastal shelf, and mentions that the latter present ideal situations for slides, particularly of the mudflow variety. These might conceivably occur in deep enough water to avoid rapid denudation, and so provide an alternative to the desert hypothesis.

GEORGE SHEPPARD.
G. H. S. BUSHNELL.

REVIEWS.

KOHLENWASSERSTOFFÖLE UND FETTE. By Prof. Dr. D. Holde. 7th Edition. Berlin: Julius Springer, 1933. Pp. xii.+1046.

The seventh edition of this standard work will be welcomed. This edition is considerably enlarged (1046 pages), and gives full descriptions of all existing standard methods of any importance. The volume is unusually comprehensive, as in addition to standard German methods, A.S.T.M., I.P.T. and French methods are given. The work completely supersedes previous editions, as a large portion of the book deals with the work of the last few years.

If the volume has any fault at all, it is the very small one that in his efforts to make the volume a complete record of available information the author has occasionally retained a method which is at least obsolescent.

This edition will be of the greatest value to petroleum chemists; in fact, it will probably be regarded as indispensable. J. S. JACKSON.

DIE ENGLISCHEN ERDÖLINTERESSEN IN RUMÄNIEN. Dr. Ing. L. Segalle. Berlin: Verlag für Fachliteratur, 1933. Pp. 122.

The motive which inspired this strange publication emanating from a Berlin-Vienna publishing house is not very clear, but it is obvious that the author has used Ludwell Denny's book, "We Fight for Oil," as a basis for much of its contents.

British methods of "Expropriation" are likened to those of the Celtic pirates, and to the Admiralty is attributed the responsibility for the grasping attitude of British politicians whose dream was to use oil as a tool for their Imperialistic policy. The deplorable machinations of Britain are contrasted with the peaceful methods of the Germans, whose oil policy was confined solely to the well-deserved protection of the rights and properties of Germans in foreign lands. The writer deplores the failure of the Deutsch Bank's efforts in Turkey and Rumania, and particularly laments the enforced annulment of the Bucarest treaty made when the German Army occupied Rumania.

The first 47 pages of the book consist of a repetition of the old and distorted stories of the acquisitions of the Anglo-Persian and Shell Companies and their rivalry with the Standard Oil Co. The second part deals with British development in Rumania, and the writer makes it clear that the active interest of the German banks in Rumanian oil prior to the War was part of a policy endorsed by the German Government. No concealment is made of the high value attached to Rumanian oil due to the proximity of the oil-fields to Germany and the presence of the Danube as a convenient medium of transport.

Then follows a full account of the activities of the British oil interests in Rumania, and concludes by paying a high tribute to their useful influence in that country.

The author writes: "The oil industry of Rumania is too young to dispense with the services of British Companies. In this respect the English influence was a great value, and their co-operation has provided the necessary experience and enterprising spirit. The efficiency and high technical standard of the oil industry in Rumania is the result, first of all, of the English co-operation. Without British capital their developments would have been impossible. The British influence has also well-balanced the aspirations of other foreign groups."

On perusing the list of 61 British Companies which have invested money in Rumania it will be remarked how few have paid any adequate return on the capital, and the majority have received no financial reward for their enterprise and energies, so that one is led to wonder what benefit Britain has derived from its oil activities in that country. A. BEEBY THOMPSON.

REPORT OF THE FUEL RESEARCH BOARD FOR THE YEAR ENDED MARCH 31ST, 1933, WITH THE REPORT OF THE DIRECTOR OF FUEL RESEARCH. London: H.M. Stationery Office, 1933. Pp. viii.+140. 2s. 6d. net.

According to the Report, the general policy and functions of the Board have been reviewed during the year, both by the Advisory Council of the Department, the Chairman of which is Lord Rutherford, and by the Board itself. This survey has included the whole of the arrangements for the direction and conduct of the investigations on fuel problems.

The Objects of Fuel Research.—"The prosperity of the country," the Report states, "in the past has rested largely upon the use and sale of coal, one of our most important national assets. The scientific study of the utilisation of our coal resources should have for its objects not only the well-being of our great mining industry; it should help to increase the competitive power of our manufacturing industries by lowering costs of production and increasing the efficiency of coal utilisation; it should make the country less dependent upon imported fuels, and should contribute to the amenities of life by diminishing the smoke nuisance."

The Economical Use of Fuel.—Surveying the problem in further detail, Dr. F. S. Sinnatt, the Director of Fuel Research, writes:—

"Where large quantities of steam are required, either for the production of power, or for process work, raw coal can be used with great efficiency, since large modern steam-raising plant operates at a thermal efficiency of well over 80 per cent. Where small quantities of heat are required, however, or where high temperatures and close control are necessary, it is often advantageous and sometimes essential to use coke, gas or electricity.

"Oil has advantages over coal in ease of handling and of control, but is more expensive; gas and electricity, on the other hand, have these advantages in a still greater degree, where they can be supplied from gas undertakings or power stations, and in such cases the only advantage of oil lies in its price. Any developments that will reduce the cost of the production and distribution of gas and electricity will result in the increased use of a

derivative of coal, instead of an imported fuel. Where small and light portable power units are required—*e.g.*, for road vehicles and aircraft—liquid fuel has advantages which may make it the only practicable fuel; but there are cases, particularly for the heavier types of vehicles, where gas can be used, either carried compressed in cylinders or made as required in a portable gas-producer from a solid fuel. Steam-driven vehicles using coal or coke as fuel, which were the earliest form of mechanical transport, are still being improved."

Carbonisation of Coal.—"Anything that will encourage the use of coal," Dr. Sinnatt continues, "or fuels derived from coal, and reduce the amount of imported oil used, will obviously assist the coal industry." The most important method of deriving more valuable fuels from coal, he suggests, is that of carbonisation, the products resulting from it being gas, coke and tar.

Motor Spirit from Tar.—It has been found that certain tars produced by low-temperature carbonisation can be converted into motor spirit by a hydrogenation cracking process, with a yield of nearly 100% by volume with the elimination of tar and acids. Considerable progress has been made with the erection of a plant capable of dealing with 300 gallons of tar a day, designed to test the commercial possibilities of this process. Pending the completion of this plant, considerable information regarding the mechanism of the process is being obtained from work on small convertors.

Pulverised Fuel.—A considerable amount of work has been done during the year on pulverised coal, which, the Report states, has "for many purposes advantages in ease of handling and control approaching those of oil fuel, while at present prices it is considerably cheaper."

Coal Oil Fuel.—"A mixture of finely-ground coal and fuel oil can, if stable, be used instead of fuel oil, as has been shown recently by the Cunard Company. Investigations on the conditions necessary to secure suspensions from which the coal will not settle out are in hand."

The results given in the Report show clearly that it is possible to produce extremely stable suspensions in the laboratory at any rate.

"A further possible line of advance consists in the development of an internal combustion engine using powdered coal, instead of gas or oil. The difficulties are obvious, but developments elsewhere are being carefully watched."

Coal as a Raw Material for the Chemical Industry.—A study of the Report shows that apart from the better utilisation of coal as fuel, a great deal of attention is now being devoted by the Board to coal and to the products derived from it as possible raw materials for the chemical industry. For instance, it has been found that cresols from coal tar can be hydrogenated without pressure to produce toluene, which is not only a motor spirit, but an important product in the manufacture of dyestuffs and explosives. Again, the work on hydrogenation of coal itself, carried out at the Fuel Research Station, is now being mainly directed to the study of the constitution of coal and of the intermediate products formed during the process, rather than to its application as a means of producing motor spirit. Much work is recorded

in the Report on the effect of catalysts, that is, the materials which have to be present to persuade the hydrogen to combine readily with the constituents of coal. One outstanding point which appears is the remarkably small amount of certain catalysts which may be needed. With some tin compounds the amount required is only 67 thousands of 1% of the coal substance.

The Report refers to the importance of taking into account the minute constituents of coal, and states that a spectroscopic examination is being made of the ashes of a number of coals selected on account of the facility or difficulty with which they may be hydrogenated. One object in view is to find coals containing the metal germanium, as this has been found to be one of the best catalysts. The subject of the fundamental constitution of coal is being approached from another angle, the laboratory work being carried out on behalf of the Board by Professor Bone at Imperial College on the oxidation of coal and on the action of solvents on coal.

INDEX.

Acid Sludge, 629
Acid Refining, use of centrifuge, 9–15
  use of Holley-Mott washer, 957–970
Air Survey, oblique method, 81–82
  equipment for, 84–87
  vertical method, 80–81
Aircraft, use for survey and transport, 73–97
Alberta, bitumen, hydrogenation of, 554
Alcohol Fuels, 562–563
Amylene, methanol solubility in, 319
Analysis and Testing, progress of, 636–651
Annual Dinner, fifteenth, 925–945
Annual General Meeting, twentieth, 285–300
Annual Report of Council, 1932, 275–284
Anti-Knocks, patents on, 560–561
Argentina, crude oils of, 554
Aromatics, hydrogenation of, 784–799
  removal of, 711
Asphaltites, Estonian, 215–222
Asphalts, chemical composition of, 671–672
  progress in, 617–627

Benzine, physical properties of, 4
  sweetening of, 963
Benzole, motor, physical properties of, 302
Benzole Mixtures, methanol solubility in, 321
Bitumen, asphaltic, analysis of, 645–647
  ductility and plasticity, 200–201
  elasticity of, 180–181
  melting point and plasticity, 200
  penetration and plasticity, 197–199
  plastic properties of, 176–212
  plasticity, cause of, 201–203
  thixotropy of, 181
  viscosity determinations, 181–197
Burma Crude Oil, refining of, 364–375
Butane, liquefied, use of, 550–551
By-Laws, alteration to, 295

Canada, refinery progress, 1932, 498–501
Candles, manufacture of, 155–171
Carbon Black, 630
Centrifuge, use for acid refining, 9–15
  use for dewaxing, 1–9
Cement, oil well, mixing and placing of, 1017–1034
  progress of, 461–462
Chemical Products, from natural gas, 551–553
Chemicals, synthetic, from petroleum, 632–633
Chemistry of Petroleum, progress of, 1932, 655–672
Coke, petroleum, 629
Colour Reversion, lubricating oil, 364–375
Cracking, by-products of, 517–520
  chemistry of, 663–666
  equipment for, 521–527
  liquid vapour-phase, 511–514
  progress of, 1932, 504–528
  reaction in, 507–511
  vapour-phase, 514–515
  with oxidation, 516–517
Crude Oil, analysis of, 636–637
  aniline points of, 709–710
  origin of, 655–657
Crude Oils, various, 554–556
Cyclohexane, methanol solubility in, 319
Cyclohexene, methanol solubility in, 319

Detonation, ozone as inducer of, 835–844
Dewaxing, 547–548
  by centrifugal separation, 1–9
Diesel Fuel Oil, progress in, 1932, 593–597
Diethyl - methyl - ethylene, methanol solubility in, 319
Distillation, laboratory, 647–649
Distillation Equipment, progress in, 9132, 529–538
Distillation Systems, comparison of, 819–834
Drilling, cable, progress of, 1932, 459
  rotary, progress of, 1932, 448–455
Drilling Equipment, progress of, 1932, 459–461
Drilling Power, progress of, 1932, 466–467

Electrical Surveying, progress of, 444–447
Engines, compression-ignition, combustion and injection in, 213–214
  use on railways, 726–732
  gasoline, progress in, 1932, 567–569
  high-speed, direct injection, 899–902
  exhaust smoke, 895–897
  fuel affect on performance, 713–724
  fuel oil for, 902–904
  maintenance of, 904–908
  pre-chamber, 987–999
  use for road transport, 885–924

Engines—*cont.*
oil, aircraft, 615–616
for road vehicles, 612–614
locomotive, 610-611
marine, 606–610
progress of, 1932, 600–616
stationary, 601–605
Estonia, asphaltites of, 215–222
Ethyl Alcohol, physical properties of, 302
Ethylene, polymerisation and decomposition of, 800–811

Fatty Substances, conversion into hydrocarbons, 773–783
Fire Prevention, progress in, 1932, 496
Flow Meters, integration and pulsation errors in, 25–68
Fuel Oil, for high-speed engines, 902–904
progress, in 1932, 597–599

Gas, flow measurement, errors in, 25–68
natural, chemical products, 551–553
chlorination of, 553
conservation of, 553
gasoline extraction, progress of, 1932, 477
odorization of, 550
oxidation of, 552–553
progess in, 1932, 549–553
pyrolysis of, 551–552
transport of, progress in, 1932, 492, 494
Gas Lift, principles of, 687–700
progress in, 1932, 467–470
Gas-Liquid Mixtures, flow of, 694–700
Gas Oil, analysis of, 641, 701–712
progress in, 1932, 592–593
Gasoline, analysis of, 638–640
aviation, 563
methanol solubility in, 321
casing-head, methanol solubility in, 321
cracked, methanol solubility in, 321
treatment of, 966–968
gum formation in, 564–566
methanol solubility in, 321
natural, progress in, 1932, 550
No. 1 Grade, physical properties of, 302
progress in, 1932, 557–566
Gasolines, dyes in, 566
properties of, 557–558
vapour locking properties, 564
See also Motor Fuels.
Gases, analysis of, 637–638
liquefied, 629
Geology of Petroleum, progress of, 1932, 427–436
Geophysics, progress of, 1932, 437–447
Germany, crude oils of, 555
refinery progress, 1932, 497

Heptane, methanol solubility in, 319
Hexahydromesitylene, hydrogenation of, 792–793
Hexamethylbenzine, hydrogenation of, 794–799
Hexamethylcyclohexane, hydrogenation of, 798
Hexane, methanol solubility in, 319
Holley-Mott Washer, 957–970
Hydrocarbon Oils, analysis of, 701–712, 1035–1037
Hydrocarbons, knock-ratings of, 559–560
pure, preparation of, 658-661
Hydrogenation, refining by, 543–544

Inclinometers, progress in, 1932, 463–466
India, refinery progress, 1932, 501–502
Insecticides, 630–631

Japan, crude oils of, 555

Kerosine, burning properties, 574–576
progress in, 1932, 574–577
refining of, 576–577
smoke point test for, 812–814
Knock-Rating, ozone effect on, 837–844
progress in, 1932, 569–573

Locomotives, oil driven, 725–732
Lubricants, progress in, 1932, 578–591
Lubricating oil, analysis of, 641–643
analytical steam distillation of, 336–363
colour reversion characteristics, 364–375
viscosity determinations, 643–645
Lubrication, progress in, 1932, 578–591

Magnetic Surveying, progress of ,442–444
Maps, underground contour, 974
Measurement, oil, progress in, 1932, 495–496
Mesitylene, hydrogenation of, 784–793

Methanol, miscibility of, 318–324
physical properties of, 302
synthetic, use as motor fuel, 301–331
Methanol Blends, distillation curves of, 330
Methanol-Gasoline Mixtures, blending agents for, 324–327
knock-rating of, 317–318
water effect on, 327–330
Methanol-Hydrocarbon Mixtures, constant boiling-points of, 331
Methyl Cyclohexane, methanol solubility in, 319
Migration, oil and gas, 229–274, 425, 740
Mining for Oil, progress of, 1932, 477–479
Mississippi, crude oils of, 554
Motor Fuels, 561–563
knock-rating of, 334
synthetic methanol as, 301–331
toxity of, 563
See also Gasoline
Mud, drilling, progress in, 1932, 455–458
Mud Flow, 878–884
Mud Volcanoes, nature of, 751–755

Naphthenes, properties of, 1036
Naphthenic Acids, 628–629

Octene, methanol solubility in, 319
Oil Shale, Estonia, composition of, 657
Oilfield Waters, analysis of, 651, 679–686, 845–862
Dutch East Indies, iodine content of, 658
Grozni, radium content of, 658
sodium analysis, 845–862
Oilfields, study of, 142–148, 223–226
technical records for, 971–1016
Oklahoma, crude oils of, 554
Origin of Petroleum, 773–783
source sediments, 117–141
Oxidation, chemistry of, 667–671
Ozone, as knock inducer, 835–844

Paraffin Wax, 631–632
Paraffins, preparations of, 701–704
properties of, 1035
Patagonia, crude oils of, 554
Pentane, methanol solubility in, 319
Peru, crude oils of, 554
refinery progress, 1932, 502–503
Pipe Lines, gas, 549–550
progress of, 1932, 479–490
Poland, refinery progress, 1932, 497–498
Polymerisation, chemistry of, 662–663
Production of Oil, care of wells, 473–474
flowing, progress of, 1932, 470, 473
gas lift, progress in, 1932, 467–470
Propane, liquefied, use of, 550–551

Refining, chemical and physical, progress in, 1932, 539–548
vapour-phase, 544–546
Reviews :
"Accuracy of Routine Analytical Determinations on Coal and Coke," 955–956
"Aerial Survey Operations in Australia," 954
"Analysis of Oil for the Production of Lubricants," 816–818
"A.S.T.M. Standards," 953
"A.S.T.M. Standards, Index to," 72
"Bituminous Emulsions for use in Road Works," 150–151, 740–742
"British Chemicals and their Manufacture," 152
"Catalytic Oxidation of Organic Compounds in the Vapour Phase," 149
"Chemical Engineering and Chemical Catalogue," 426
"Chemical Refining of Petroleum," 952–953
"Chemistry and Technology of Cracking," 332–333
"Directory of the British Chemical Plant Manufacturers Association," 152
"Earth Oil," 818
"Englischen Erdölinteressen in Rumänien," 1039
"Fuel Research Board Report," 1040
"Geology of California," 815
"Kohlenwasserstöffe und Fette," 1039
"Lubricating and Allied Oils," 227–228
"Origin and Environment of Source Sediments of Petroleum," 303–334
"Petrole en Roumanie," 151
"Petroleum Development and Technology, 1933," 946–951
"Petroleum Vademecum," 72
"Progress of Applied Chemistry," 227
"R. E. F. U. T. A. S. Viscosity-Temperature Chart," 815–816
"Symposium on Motor Lubricants," 953–954
"Turner Retort, Report of Tests on," 72
"Viscosity of Pitch," 954–955

Road Materials, progress in, 1932, 617–627
Rumania, refinery progress, 1932, 498
Rumanian Branch, sixth annual dinner, 733–739

Sedimentary Volcanism, nature of, 743–772, 1037
Seismic Surveying, progress of, 440–442
Separators, oil and gas, progress in, 1932, 476
oil and water, progress in, 1932, 476–477
Solvent Extraction, 546–547
Solvents, hydrocarbon, 630
Special Products, progress in, 1932, 628–635
Storage, oil, progress in, 1932, 494–495
Surveying, use of aircraft for, 73–90
Sulphur, determination of, 640–641
Sulphur Compounds, chemistry of, 666–667

Tank Steamers, progress of, 1932, 491–494
Tests of Petroleum, physical, 649–650
standard, 652–654
Texas, crude oils of, 554
Torsion Balance, use of, 439–440
Transformer Oils, 634
Transport, use of aircraft for, 91–97
Trinidad, mud flow in, 878–884
refinery progress, 1932, 502
sedimentary volcanism in, 743–772
Trinidad Branch, second annual dinner, 69–71
Trichlorethylene, dewaxing solvent, 4–9
physical properties of, 4
Trimethyl Ethylene, methanol solubility in, 319
Trimethyl Pentane, methanol solubility in, 319
Trimethyl Pentene, methanol solubility in, 319
Twitchelling Process, 163

United Kingdom, petroleum imports, 1930–32, 676–677
United States, motor fuel production, 1931–32, 674
petroleum production, 1930–32, 674

Viscometer, capillary, 181–184
Couette concentric, 184–186
suspended level, 376–420
Viscometry, 643–645
Volatility Range, lubricating oils, 336–363

Water, location of, 458–459
Waxy Substances, conversion into hydrocarbons, 773–783
Wells, care of, progress in, 1932, 473–474
drilling records, 976–985
logs of, 973
pressure recording in, 474–475
production records, 985–989
restricted, behaviour of, 863–877
temperature recording in, 475–476
surveying of, progress in, 1932, 463–466, 474–476
World, motor fuel consumption, 675
petroleum production, 1930–32, 673
World Petroleum Congress, 421–425
Wyoming, crude oils of, 554

l solu-
l solu-

mports,
luction,
32, 674

y oils,

n into
1932,

5
877
–476
2, 463–

, 675
930–32

–425